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MEMOIRS OF THE GEOLOGICAL SURVEY.

SPECIAL REPORTS ON THE MINERAL RESOURCES OF GREAT BRITAIN.

NGI STORAGE

VOL. XXV.—LEAD AND ZINC ORES OF NORTHUMBERLAND AND ALSTON MOOR.

BY STANLEY SMITH, M.A., D.Sc.,

WITH CONTRIBUTIONS BY

R. G. CARRUTHERS.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HIS MAJESTY'S TREASURY.

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PREFACE.

This Memoir deals with one of the oldest and most productive lead mining regions of Britain, including most of Alston Moor. Descriptions are given of many valuable fields, such as those of the Middle Tyne Valley, of which no account has been published hitherto.

The field work, almost wholly executed by Dr. Stanley Smith, was done in 1918, the office work and writing of the MSS. being completed in 1919. Most of the editorial work was done by Sir Aubrey Strahan previous to his retirement from the Survey in 1920; it has been completed by Mr. Carruthers, who is also responsible for the short account of the South Tyne areas, finished in 1921, and for the Introduction.

Generous help has, without exception, been afforded by estate and mine owners, mining officials, and others. In particular, we wish to thank Mr. J. C. P. Walton, Messrs. Wm. and Sydney Watson, and the officials of the Vieille Montagne Zinc Company. Access to the remarkable collection of plans and sections at the Allenheads Mining Office was freely given by Lord Allendale and his agents. Mr. J. W. Metcalfe has been particularly helpful, while Mr. J. B. Atkinson, Mr. H. W. Cousins, Professor Henry Louis, Mr. Wm. Thompson, and Mr. John Westgarth also gave material assistance.

JOHN S. FLETT,
Director.

Geological Survey Office,
28, Jermyn Street,
London, S.W.1.,
8th November, 1922.

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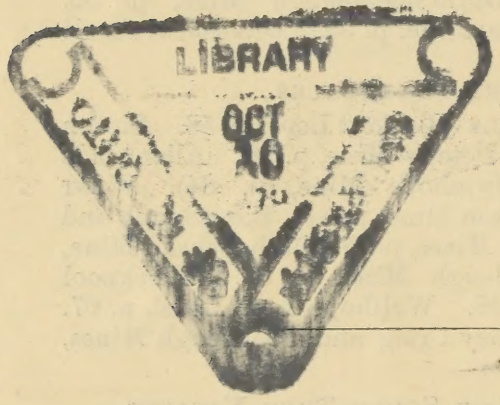


LEAD AND ZINC ORES

OF

NORTHUMBERLAND AND ALSTON MOOR.

CHAPTER I.

INTRODUCTION.

The broad ridge of the Pennines, running from the English Midlands up to the Scottish Border, is marked by continuous outcrops of Lower Carboniferous strata, amply exposed in the ranges of hilly ground to which they give rise. These rocks, particularly those of the Carboniferous Limestone divisions, are extensively mineralised in Derbyshire, and again in a group of northern dales (Allendale, Alston Moor, Weardale, and Teesdale); the intervening tract, in Yorkshire and Lancashire, is very much poorer, though there are localised vein complexes in Swaledale and Upper Wharfedale. Beyond the dale region, in Northumberland, mineral veins are few and far between, and north of the Roman Wall are of slight account.

Of the two great rock groups in which the veins are found, the Millstone Grit is the most constant in character. This great assemblage of arenaceous deposits covers immense areas in northern Derbyshire, in Yorkshire and Lancashire, but rapidly dwindles further north, along the western margin of the Newcastle Coalfield. In certain parts of West Yorkshire (Pateley Bridge and Grassington), the Grits are traversed by highly productive veins, but elsewhere the formation is poorly mineralised, behaving as a "Farewell Rock" to the lead miner almost as much as to the collier.

The great majority of the lead-zinc deposits are found either in the Carboniferous Limestone or in the overlying Yoredale Series.

As is well known, there is a pronounced change of facies in these rocks as they are traced in a northerly direction (*see* Plate 1), and the main ore-bearing horizons change also. In Derbyshire the Limestone massif alone carries ore, and the Yoredale Shales are barren: going north these conditions are reversed, and it is in the sandstones, shales and limestones of Yoredale age that the best lodes are found: the great basal limestones of Ingleborough and Melmerby, remnants of the Derbyshire massif, are almost entirely barren.

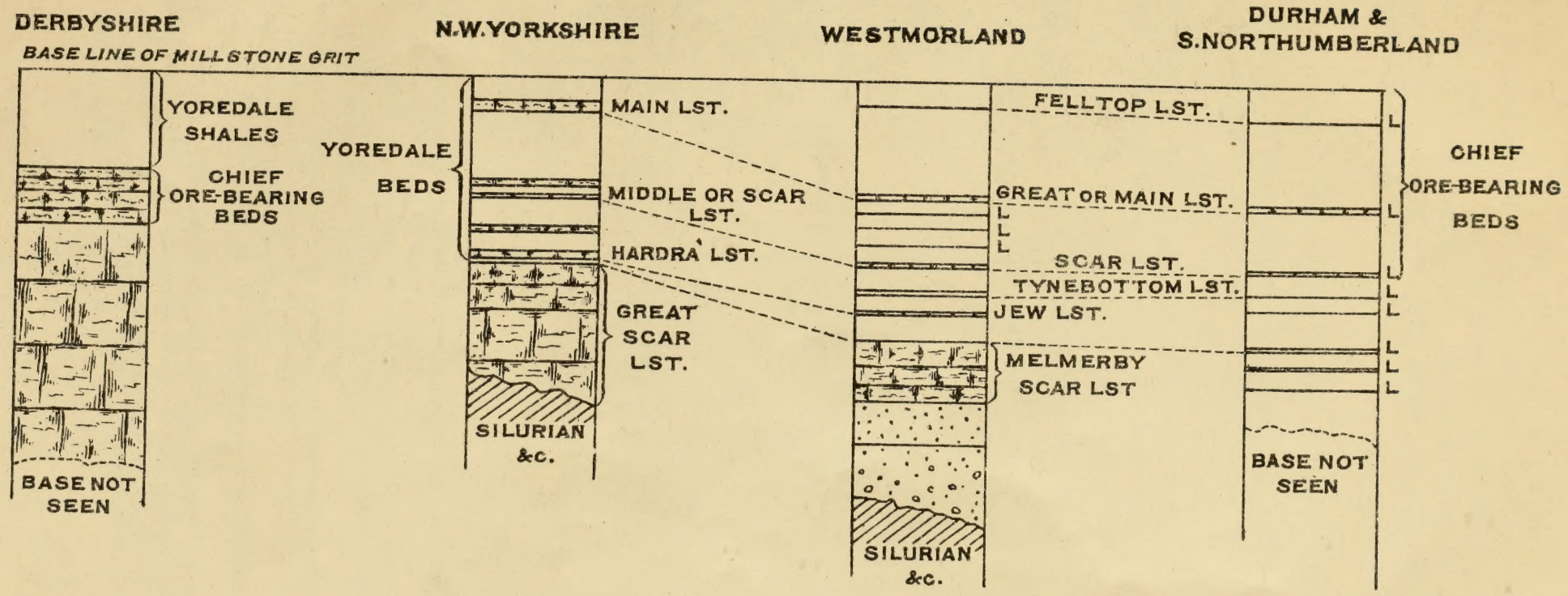
The lead, zinc, and copper ores of the Pennines are accompanied by gangue minerals of economic value, such as fluorspar and barytes, besides calcite: quartz occurs in the northern districts only, and even there is of small account. The predominant ore everywhere is galena; zinc ores (principally blende) are only of value in the Alston Moor-Allendale fields, and at a single mine, Millclose, in Derbyshire; copper ores are comparatively rare, and the few mines opened have now been idle for many years.

In all the mineral districts, veins of the fissure type, frequently accompanied by faulting, are the rule. In addition, deposits arising from the infilling of previously formed cavities ("chamber deposits") are particularly common in Derbyshire, while in some of the northern fields (Alston Moor and Weardale) galena bodies, due to extensive metasomatic replacements, are a noteworthy feature.

In general the veins are thin and poor when they traverse shales, but carry well in sandstones and limestones, evidently because such strata lend themselves to the formation of wide open fissures suitable for ore deposition; the metasomatic ore-bodies are confined to limestone beds.

There is generally a rapid impoverishment in depth, so that very few mines are over 100 fthms. deep. Near the surface there may be an oxidation zone, marked in Cumberland and Durham by cerussite and an abundance of iron ores, frequently showing cores of galena, and in Derbyshire by the conversion of most of the lead and zinc sulphides to carbonate and silicate. A further effect in the Northern Pennines was seen in the high silver yield, amounting at times to 30 ozs. per ton, of lead ores at or near their outcrop; in the deeper levels now wrought 6 ozs. per ton is the rule. Within the primary zone lead and zinc ores are represented by galena and blende only, and there is certainly no general increase of blende and copper ores in depth. In the Pennines such ores can almost always be ascribed to regional changes in the composition of the mineralising waters, or else (especially in the case of the copper ores) to impregnations of somewhat different date from those which provided the galena bodies.

In the northern regions water trouble is generally of no great moment, but in Derbyshire it is often serious; in that county some of the great drainage levels yield as much as 15,000 gallons per minute, and much good ore has had to be left untouched in the bottom levels of some of the mines. There is no doubt that the industry is, at the present time, severely handicapped by the high cost of production; nevertheless, even were this removed, it must be frankly admitted that, so far as the Pennines are concerned, the great days are long past. The steady decline in output since 1877 (*see* Plate 2), though no doubt hastened by the low prices prevailing over the period 1890–97, is in the main due to the



Lower Carboniferous Rocks of the Pennines.

Scale: 1,000 ft. to 1 Inch.

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exhaustion of the ore bodies. The fall would be very much greater had the returns for the two leading producers, Boltsburn Mine in Weardale and Millclose Mine in Derbyshire, been omitted. These concerns owe their prolonged activity to the fact that in their case continuous lateral extensions of the workings have been possible, and they have not been driven to rely on deeper levels only.

Geological Relations of the Lodes.

The succession of the Lower Carboniferous sediments in the North of England is shown in the comparative table below.[1]

Northumberland, north of Tyne.		Alston Moor.	
Upper Bernician (exposed in the Tyne Valley and neighbourhood).—Alternations of sandstones and shales, marine limestones, and coal-seams	2,600 ft.	*Upper Limestone Series.*—Similar, but limestones thicker. Coal seams fewer and inferior	1,300 ft.
Lower Bernician (concealed in the Tyne Valley but exposed round Bellingham).—Sandstone, shales, coals, calcareous grits and a few thin marine limestones (the last-mentioned die out northward)	2,500 ft.	*Melmerby Scar Limestone Series.*—Limestone, with subsidiary shales and sandstones near the top and the base	300 ft.
Upper Tuedian or Fell Sandstone Series (concealed in the Tyne Valley, but exposed in Redesdale and around Kielder). — Sandstones and grits of a prevailing red tint, subsidiary shales	600 ft.	Sandstones and shales (equivalent to the *Roman Fell Conglomerate* in the Pennine Escarpment)	900 ft.

[1] Particulars concerning the Carboniferous Limestone series in this part of England will be found in the following works:—

"An Account of the Strata of Northumberland and Durham as "proved by Borings and Sinkings." *North of England Inst. Min. and Mech. Eng.*, 1878–1910. Seven volumes.

"A Treatise on a Section of the Strata from Newcastle-upon-Tyne "to the Mountain of Cross Fell, &c.," by Westgarth Forster. Revised Edition edited by W. Nall, 1883.

"Outlines of the Geology of Northumberland and Durham," by G. A. Lebour, 1889.

"Report of the Committee appointed to report upon the "Carboniferous Limestone Formation of the North of England, with "special reference to its Coal Resources," by Stanley Smith, 1912. *North of England Inst. Min. and Mech. Eng.* (This report contains an extensive bibliography.)

Northumberland, north of Tyne.		Alston Moor.
Lower Tuedian.—Cement-stone group (concealed in the Tyne Valley; exposed in Redesdale and around Kielder). Brightly coloured shales, cement-stones, and subsidiary sandstones more arenaceous towards base - -	600 ft.	

In Northumberland these strata incline gently eastwards, but veer round to a southerly direction towards the Tyne Valley, south of which there is an important E.–W. belt of fracture (the Stublick and Ninety Fathom Dykes, &c.).

The lead-veins are almost wholly confined to the higher part of the Upper Bernician and the equivalent horizon in the Alston Series. North of the Roman Wall a few strings have been met with in lower parts of the Carboniferous Limestone sequence and traces of galena and blende in the Old Red Sandstone lavas and Silurian slates, but they are of no economic importance.

The veins are decidedly local in their distribution. The richest belt, along the south side of the area, includes the famous Alston Moor and Allendale fields, while there is another well mineralised tract to the north, between Corbridge and Haydon Bridge.

The usual trend of the lodes is N.E.–S.W., but some strike almost due east and west, while others bear N.N.E.–S.S.W. or take even a more northerly course. All these are termed by the miners "the east-and-west veins." They are intersected by another series of faults running N.W.–S.E. or due north and south, which are known as the "north-and-south veins" or the "cross-veins." These are for the most part unproductive, but not wholly so, and there is a general belief that they increase the productiveness of the "east-and-west veins" they intersect. As a class they appear to be of later formation than those veins.

Most of the veins are liable to branch, giving rise to "north veins" and to "south" or "sun veins." Minor veins or "strings" leave the main lode at frequent intervals and some of these curve round and rejoin the parent lode, the loop thus formed being known as a "horse." Veins generally, sooner or later, split up into strings.

The productive veins, with some notable exceptions such as the Fallowfield, are normal faults of small throw and slight hade. They exhibit a tendency to become more vertical and

wider in hard limestones and sandstones than in softer beds such as shales[1]. It should also be remembered that the softer beds yield more readily to pressure, and therefore joints are less likely to remain open.

The contents of the veins frequently show indications that movement has taken place subsequent to their deposition. They exhibit displacement strains, cleavage parallel with the sides, and slickensiding within the mineral mass, &c. (*See* description of the Esp Vein, pp. 57–59.) They also bear signs of some solution and additions, for example, the intercalation of strings of one mineral in another, and the occurrence of negative crystals.

As regards width, the veins range from 4 to 12 feet, but some far exceed these measurements. They fall under three types, all of which may be illustrated in the same vein :—

(*a*) Clean open fissures occupied by a solid wall of mineral.

(*b*) Fissures filled by broken country-rock that has fallen in from the sides or from above, and has been cemented by mineral.

(*c*) Zones of fracture on one or both sides of a fault, consisting of innumerable cracks filled by vein-material.

In certain limestones, above all in the Great Limestone, the veins are frequently associated with extensive and valuable ore-bodies, due to metasomatic replacement, locally known as "flats."

The dominant mineral in the veins may be barytes, witherite, fluorite, blende, ochre or calcite. Galena is associated with all these minerals, but generally in subordinate quantity. Quartz and siderite are invariably present; pyrites is only found in insignificant amount, whilst chalcopyrite is rarer still, save in some veins on Alston Moor. Veins, however, vary in their contents from place to place, sometimes abruptly, as in the case of the High Raise Vein (p. 83), and the Settlingstones Main Vein (p. 29).

The following notes on the distribution of the minerals are made with some reservation, since few veins are now accessible, and those only for a limited distance. In some cases spoil-heaps have been the only source of information :—

Barytes.—Opaque, white, yellow or flesh-coloured; often associated with large bodies of galena.

Occurrences: The Tyne Valley, West Allendale and the Derwent Valley eastward from Edmondbyers.

---

[1] The phenomena were described at length and copiously illustrated by John Leithart in 1838 in "Practical Observations on the Mechanical Structure, Mode of Formation, the Repletion or Filling Up, and the Intersection and Relative Age of Mineral Veins, &c." Leithart was a practical and observant man, who had intimate knowledge of the veins of the district.

Witherite.—Translucent to opaque, colourless or white; rarer than barytes, and not accompanied by so much galena.

Occurrences: The Tyne Valley, West Allendale, and the Nent Valley.

Settlingstones Main Vein is the widest and purest deposit of witherite in this country. Elsewhere, much barytes or baryto-calcite is present.

Fluorite.—White, yellow to brown, green, and purple; crystals often well formed. The fluorite veins have yielded rich supplies of galena.

Occurrences: The Derwent Valley, West of Edmondbyers, and East Allendale.

Blende.[1]—Dark brown and opaque, with a metallic rather than resinous lustre; always associated with galena.

Occurrences: Nenthead and contiguous part of West Allendale; also the Swinhope Vein in East Allendale.

Blende frequently occurs as strings, or as crystal aggregations within a spathic vein, but only in small amounts. In the case of the "blende-veins" it takes the place of the spar and forms a matrix for the galena.

Ochre or *Umber.*—Metasomatic change of limestone (and to a lesser extent of sandstone also) into an iron-oxide (usually limonite) is not uncommon. A vein may exhibit this kind of mineralization for its whole extent, or may be affected by it in barren parts only. Blende-veins more particularly are associated with iron-oxide. Some of the limonite present in veins is undoubtedly derived from siderite.

Calcite.—Though generally to be found, is purely subsidiary; nowhere in the Tyne region does it constitute the chief vein mineral, but it forms the matrix of all those isolated veins and strings lying north of the Roman Wall.

The Shildon Veins (p. 43) carry a large amount of chalcedony associated with fluorite.

From the foregoing facts the following generalisation can be made. The barytes and witherite veins form, as far as Northumberland is concerned, a fringe bordering the metalliferous area on the east, north, and west. Within that area are found the fluorite and the blende veins, the former mostly lying to the east, the latter to the west, of the Burtree Ford Dyke, a big north-and-south fault with a downthrow to the west.

The galena in these veins may take the form of ribs a few inches or even a few feet in thickness, or may occur as thin strings, as pockets, or as isolated crystals arranged in bands or scattered promiscuously through the spathic matrix, or in the country-rock itself. When galena is in contact with the country-rock the junction may be quite sharp or may be

[1] Wallace ("Mineral Deposits," p. 177) states: "The vertical range of zinc-ore is more limited than lead ore; scarcely any has been deposited in the strata above the Little Limestone, and so far as the veins are proved, very little of it below the Great Limestone," but in describing the Guddamgill Vein (p. 176), he refers to the blende as "plentifully deposited in all strata between the Pattinson and the Tuft." Above the Little Limestone the veins are presumably narrower, contain less mineral deposit generally, and may carry some barium-spar. Blende is now being raised from beds below the Great Limestone, although it is there certainly less abundant.

indefinite, the rock being impregnated with the mineral for some distance from the string.

The depth to which the veins carry ore varies according to local conditions, but it is improbable that ore in any quantity lies at greater average depth than 100 fthms., although some workings are deeper than this where they have been advanced under rising ground. The lowest actual workings in the area are those in the Rampgill Vein (p. 76).

History of Mining.

Lead.—No record exists of lead-mining having been carried on in this region prior to the Norman invasion. That lead was used as early as the Bronze Age may be inferred from the fact that two bronze swords with lead pommels have been found at Tosson near Rothbury.[1] The spot is close to the outcrop of some lead-veins, but there is no evidence that the pommels were made in the neighbourhood.

That the Romans worked the lead-veins in the Tyne Valley, around Weardale, or on Alston Moor, can only be inferred from the fact that Roman habitations were situated close to rich veins. No pigs have been found, but the metal in one form or another has frequently been obtained from the stations on the Wall. It was used in fixing into their sockets the iron dowels which clamp together the stones in the abutment of the bridge at Cilurnum (Chollerford).[2] Cubes of galena have been found at Borcovicus (Housesteads), but do not constitute evidence of mining. A vein outcrops close to the camp.

More significant is the fact that wherever metalliferous veins occur, there are almost invariably evidences of Roman presence regardless of isolated situation. Whitley, near Alston, is the site of a station of considerable size, and Roman objects have been found in Weardale. Moreover, the Roman Wall so precisely defines the northern limit of the rich Pennine mining field, that the coincidence can hardly be accidental. This was commented on by John Phillips in 1848.[3]

Old heaps of lead-scoria are found in many exposed places around the South Tyne, the Allen and Derwent: they probably mark the site of crude furnaces such as were used in the Middle Ages and remained in use until a comparatively late date.

The earliest documentary evidence dates from the 12th century, but in this and the 13th, 14th and 15th centuries is most meagre, and vague as to the location of the mines. The documents include pipe-rolls, charters of Royal protection

[1] John Evans, "Ancient Bronze Implements of Great Britain," 1881, p. 286.

[2] "An Account of the Roman Antiquities preserved in the Museum at Chesters, Northumberland," 1907.

[3] "Thoughts on Ancient Metallurgy and Mining in Brigantia and other parts of Britain, suggested by a page of Pliny's Natural History," *Proc. Yorks. Phil. Soc.*, Vol. i, pp. 77–92.

granted to miners and writs and complaints against miners for damage to property or against those who sought to obstruct them.[1] The oldest of these is a Pipe-Roll dated 1130, in which the burgesses of Carlisle rendered an account due to Henry I. for the "Carlisle Silver Mine." The Carlisle Silver Mines have been identified by historians with Alston Moor, although Wallace[2] puts forward arguments to show that most of them lay in Northumberland. An entry in the Register of Walter de Grey[3], Archbishop of York, 1215–1256, records the lease of a mine within the Regality of Hexhamshire to a Company of miners in 1320, the payment fixed being $\frac{1}{7}$th of the produce. Edward IV. made three grants of mines affecting this region.

1468.[4] All mines of gold and silver and all mines of lead holding these metals within England north of the Trent to the Earls of Warwick and Northumberland and others for 40 years with liberty to dig without licence except under houses and castles, the dues agreed upon being $\frac{1}{11}\frac{1}{2}$th of the precious metals to the King, and $\frac{1}{11}\frac{1}{6}$th to the Lord of the Manor.

1475.[5] Shyldeyn (Shildon) Mine in Blanchland and Feccheroos (Fletchers or Fletcheras) Mine on Alston Moor to the Duke of Gloucester, Earl of Northumberland and others for 15 years, payment being $\frac{1}{8}$th of pure silver to the King, $\frac{1}{9}$th to the Lords of the soil, and $\frac{1}{11}\frac{1}{0}$th part of "lees ewrs" to the curate of the place.

1478.[6] All mines of gold, silver, copper, and lead in Northumberland and Westmoreland to William Goderswyk and other merchants for 10 years who should pay $\frac{1}{11}\frac{1}{5}$th part to the King, and to the Lords of the soil and the curate according to agreement.

Thomas Wolsey in 1518 leased all the mines in Hexhamshire to Thomas Lord Dacre for 99 years, royalty being fixed at $\frac{1}{9}$th of the produce.[7]

During the Middle Ages there appears to have been an influx of German miners into the Alston district.

Mining underwent considerable development during the latter part of the sixteenth and the whole of the seventeenth centuries. Some mines had been opened out in West Allendale in 1565 (*see* p. 55), and in 1611 Fallowfield Mine was in existence (*see* p. 21). The indigenous mining population was increased by immigrants from Derbyshire at this period, as shown by the Church Registers at Allendale and St. John's Lee (the parish in which Fallowfield lies).

---

[1] *See* "A History of Northumberland," 1893–1922, eleven volumes. "The Victoria History of the County of Durham," two volumes, 1905–7. "The Victoria History of the County of Cumberland," two volumes, 1901–1905. W. Wallace, "Alston Moor: its Pastoral People: its Mines and Miners," 1890.

[2] *Op. cit.*, p. 102.

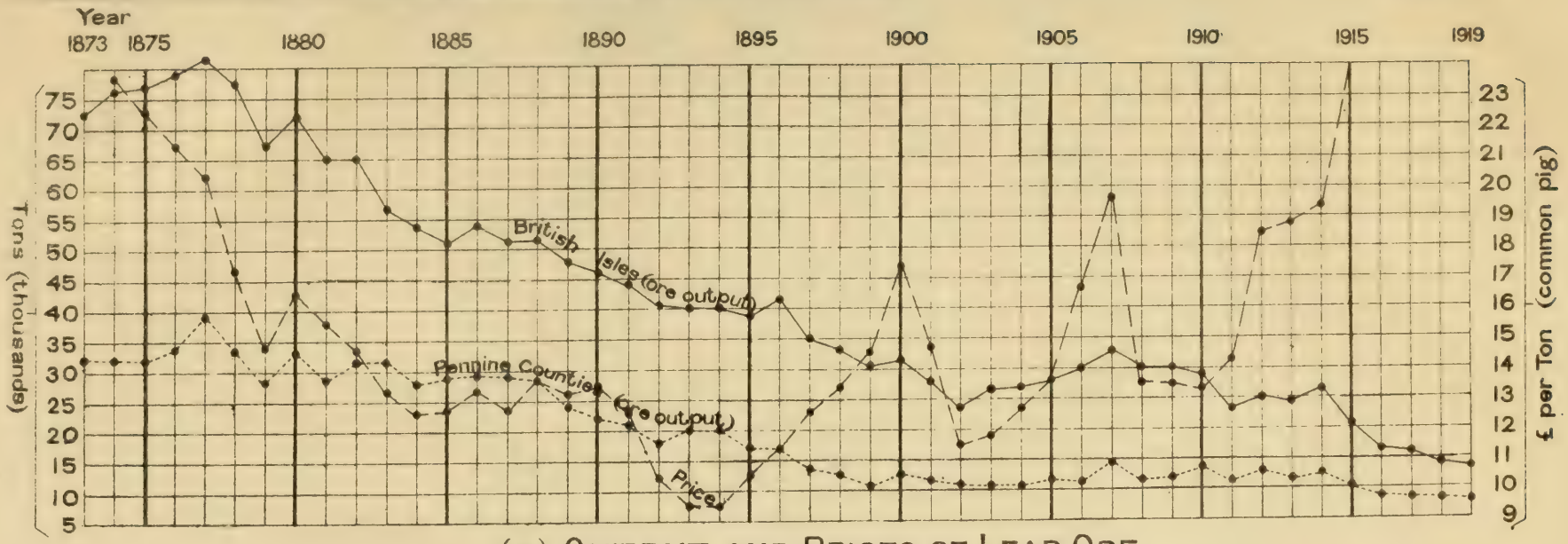
[3] Arch. Grey's Register, *Surtees Soc.*, 1872, p. 236.

[4] "Calendar of Patent Rolls," p. 132, 8 Edw. IV., Part 111, memb. 14.

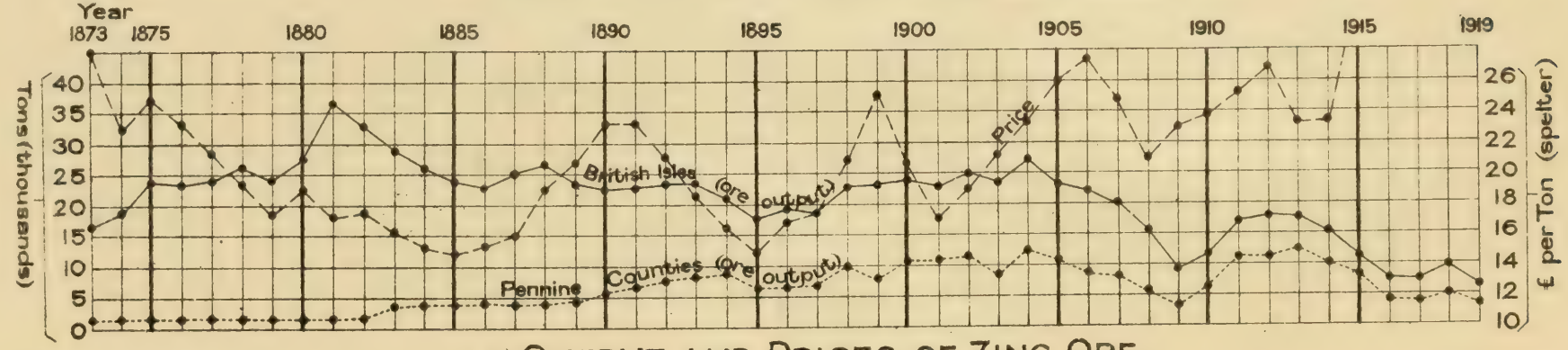
[5] "Calendar of Patent Rolls," p. 505, 15 Edw. IV., Part 1, memb. 22.

[6] "Calendar of Patent Rolls," p. 116, 18 Edw. IV., Part 2, memb. 30.

[7] Reg. Leases, York i.f. 17a.



(a) OUTPUT AND PRICES OF LEAD ORE.



(b) OUTPUT AND PRICES OF ZINC ORE.

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The closing years of the seventeenth century witnessed the acquisition of the Allendale Mines by Sir William Blackett, and the opening decades of the eighteenth century, the advent into the north of the London Lead Company. To the able and beneficent management of Sir William Blackett and his successors and of the London Lead Company, the mining industry is mainly indebted for its advancements and prosperity.

After a depression in the earlier part of the eighteenth century mining revived during its later years and continued to develop until in the middle of the nineteenth century, when it reached its highest point. From 1870 onwards it declined, slowly at first, but rapidly during the next two decades, until the low price to which lead fell in 1894 (9*l.* 10*s.*) all but extinguished the industry; of the 98,000 tons of lead ore raised within these islands in 1870, Northumberland, Durham and East Cumberland contributed 28,500; in 1913 these counties supplied 7,000 out of the total 24,000 tons.

The methods of working the mines were described by John Wallis in 1769.[1]

"The method of our miners . . . . is by sinking a shaft till they come to a vein and then they make cross cuts, and with eager pursuit follow the several branches or strings as they are called. They had formerly another method, still practised near Rokehope, within the liberties of the bishoprick of Durham. This was by flooding or hushing as they phraze it; making a large bason or reservoir of water, which being let out by a sluice in a full stream through a cut or opening from a descent, with an irresistible impetuosity sweeps away, on frequent repetitions, all the various substances which compose the roof of the mine, freestone, ironstone, whinstone, limestone, spar, and talc and at length the ore itself, with gravel, sand and other extraneous matter in gentler currents." Evidences of these hushes and remains of the dams built across a sike or small valley, are still to be found.

The miners, who were, and still are for the most part, small farmers as well, were formerly paid under the "old bargaining system," whereby, usually in partnerships of four, they contracted to raise ore at a certain price per bing, the price demanded being determined by current values, by the difficulties of working and by the prospects of production. They received on account a fixed sum monthly, known as "lent" or "subsistence money." During the earlier part of the last century this was one pound per month, but later it was increased to three pounds. The balance was at one time paid yearly, but afterwards half-yearly. Occasionally, owing to "bad bargains" the amount earned was less than that received in advance, and the miner became indebted to his employers, or, as it was termed, "got into the Master's books." The debt stood over until the next "pays." Even at the present day a miner who is paid in respect

[1] "The Natural History and Antiquities of Northumberland, &c.," 1769, Vol. I., p. 120.

of the amount of ore raised is spoken of as being "employed on tribute." All miners are now paid their full wage at the end of the week or month, but in East Allendale they still work in partnership and contract periodically.[1]

Zinc.—Until recently blende and calamine found in West Allendale and Alston Veins were relegated to the spoil-heaps or utilised as "deads," the facts being that there was a smaller demand for zinc than for lead, and that Germany could supply spelter at a lower price than the home country. Bailey and Culley in their "General View of the Agriculture of the County of Northumberland," first published in 1797, remarked that although the ores of zinc were abundant the distance from any brass manufacturer and from water-carriage rendered them of little value.[2]

The annual returns made of zinc-ore from the Cumberland mines previous to 1870 rarely exceeded a few hundred tons, as compared with an average of about 6,000 tons during the years immediately preceding 1914, and except for some trivial amounts the Allendale Mines furnished no returns of zinc-ore until 1899, when the Vieille Montagne Zinc Company took over the Coalcleugh Mines. Between 1899 and 1918 some 50,000 tons have been raised from these workings.

The first attempt to economise the calamine was made by Richard Grey in 1794. He obtained a grant of that found in the Nenthead Fields and Haggs North Veins, and continued washing the refuse heaps of the former until about 1831. In 1817 a considerable quantity of blende was raised by Thomas Shaw and Company, chiefly from the Guddamgill and Brownley Hill Veins, and smelted at Langley Mill (*see* p. 19). A spelter mill was erected near Milton Railway Station on the Newcastle and Carlisle line by Mr. Attwood in 1845.[3] It was acquired by the Nenthead and Tynedale Mining Company, and was in use until about 1896.

Conditions and Methods of Mining.

For some years past only two mining companies, the W. B. Lead Company and the Vieille Montagne Zinc Company, have been operating in Northumberland. The former has been raising a little lead from the Esp and St. Peter's Vein at Sipton, in East Allendale, since 1912, and the latter has been working zinc and lead from the veins in the southern part of West Allendale. On the whole the industry has revived somewhat during the last ten years, and shows further signs of resuscitation.

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[1] For accounts of the older conditions of labour and payment, *see* "Thomas Sopwith," by B. W. Richardson, 1891, p. 303. Also "Allendale and Whitfield," by George Dickenson, 1903, p. 51.

[2] p. 22, 1st Edition.

[3] Wallace, "Alston Moor: its Pastoral People: its Mines and Miners," 1890, p. 160, is the authority for these historical notes.

The general methods of working are the same throughout the North of England. Levels are driven along the vein and arched over with stone or concrete blocks, or merely timbered. The roof is penetrated at intervals by "rises," from which "stopings" are extended either forwards or backwards. As the stopings are extended upwards the floor is raised by packing the excavated portion of the vein with waste material or "deads."

The floor thus constructed is temporarily boarded over to prevent loss of ore which is pulled down from the roof, and it serves also as a platform in advancing the roof of the stope. The ore is fed through shoots at the side of the workings into the wagons standing in the level below. In a few cases where the vein is "soft" (*i.e.*, the sides show a tendency to crush in), it is entered by means of short "cross cuts" from a level driven along the side.

The hilly character of the country has permitted a free use of water-levels, and most of the mines are thus adequately drained with little or no pumping. A fairly high rainfall and good natural collecting grounds for the water provide an important source of power, which is utilised at Nenthead (p. 88), and was formerly employed on an elaborate scale at Allenheads (p. 63) and Derwent Mines (p. 48).

Workable seams of coal in the Carboniferous Limestone Series constitute a special and valuable asset, more particularly in the mines of the Tyne Belt where the seams are more numerous, better and thicker than those found further south. At Fallowfield (p. 25) the lead and coal-workings were once in actual communication, and an inferior although usable seam has been cut in the Settlingstones Mine.

During recent years one of the most serious disadvantages in mining has been the risk of encountering the "old man," a term commonly employed to denote any workings of which no records exist.

Some information respecting the rents and dues demanded from the grantees of mines during the earlier centuries has already been given (p. 8). Mining accounts and reports of the last two centuries show a gradual diminution in Royalties.

At the general letting by the Greenwich Hospital of the mines on their estate in 1737, offers of a $\frac{1}{4}$ duty were made for some of the veins[1]. The London Lead Company paid the Hospital[2]

between 1737–1830	- - -	$\frac{1}{5}$th in Royalty.
,, 1830–1862	- - -	$\frac{1}{7}$th ,,
,, 1863 and afterwards	-	$\frac{1}{9}$th ,,

[1] Wallace, "Alston Moor: its Pastoral People: its Mines and Miners," Appendix II.

[2] On the authority of the Rev. W. Nall, gleaned from the Company account books.

Mine reports drawn up towards the end of the 19th century usually state $\frac{1}{12}$th to $\frac{1}{14}$th as the Royalty, but at the present time only about $\frac{1}{20}$th is being demanded.

Lead and Zinc Prices.

The price of lead was £10 per ton at the beginning of the 18th century, and it remained at, or near, this figure through the first four decades.[1] From 1737 onwards its fluctuations are shown in Plate 3, together with those of spelter from 1823.

The sources from which these figures have been obtained are:—

Lead.

1737–1809.	The original sale-books of the London Lead Company.[2] Missing figures for certain dates between 1787 and 1809 have been supplied by a table given by E. Mackenzie in his "View of the County of Northumberland," 1825, Vol. I, p. 101, or by calculations from the current price of lead-ore.
1809–1821.	Mackenzie.
1821–1855.	From prices furnished by Messrs. John Taylor and Sons, London, and Messrs. Locke, Blackett & Co., Newcastle-upon-Tyne.
1856–1918.	Official Statistics (*Home Office Reports*). "Average price per ton in the London market."

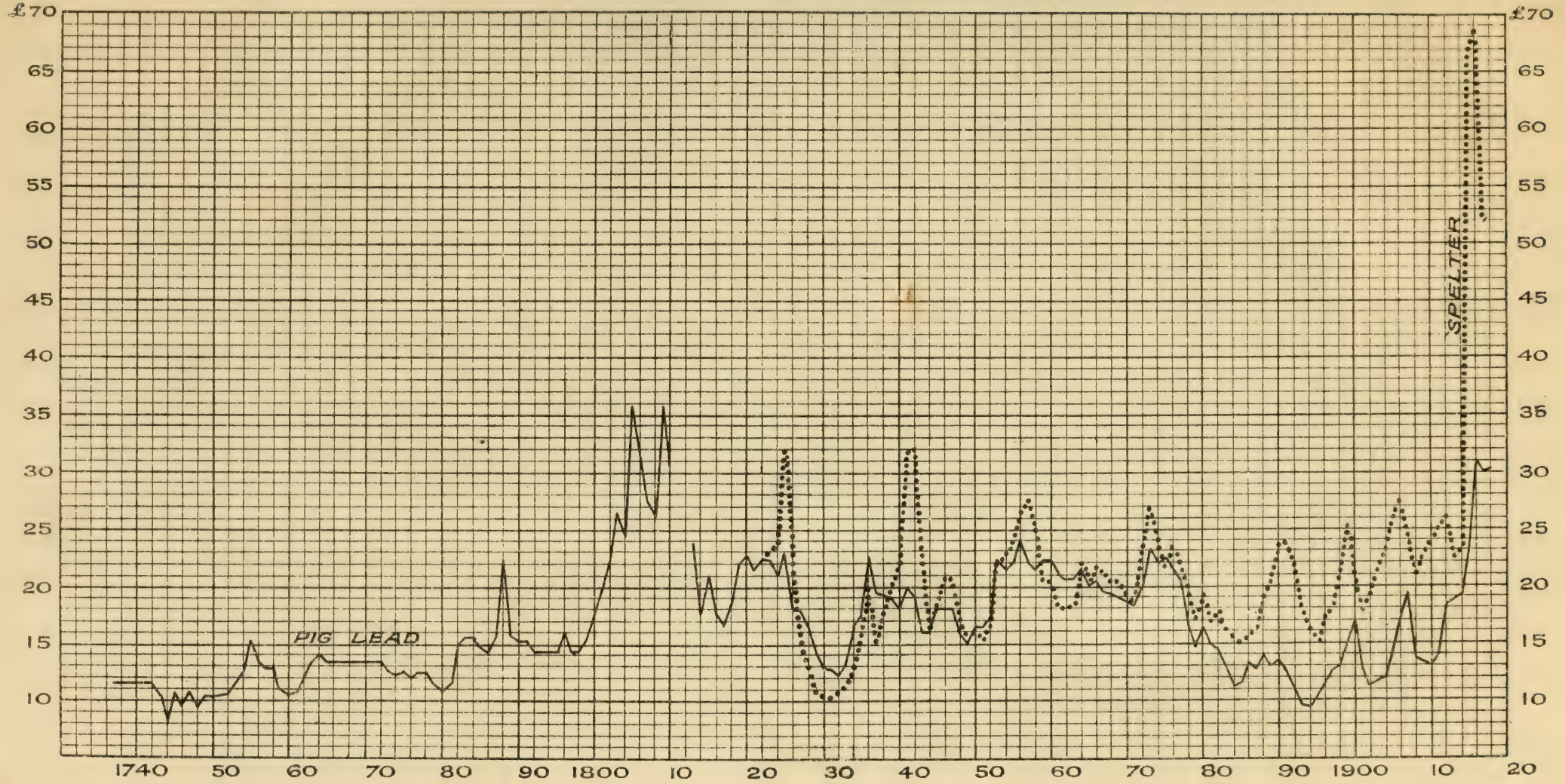
Zinc.

1823–1857.	Hunt's "Statistical Tables," 1858, p. 64.
1858–1918.	Official Statistics (*Home Office Reports*). Average price per ton of English spelter.[3]

[1] William Waller "An Essay on the Value of Mines late of Sir Carbery Price," 1698.

[2] Preserved in the library of the North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne.

[3] The earlier years, 1858–1875, merely state spelter without any qualifying remark.



PRICES PER TON OF PIG LEAD AND SPELTER.

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CHAPTER II.

DETAILED DESCRIPTIONS OF THE MINES.

AREA NORTH OF THE ROMAN WALL.

The metalliferous veins that lie north of the main area need little description. Taken in order from north to south, the notes upon them are recorded under the sheet number of the Old Series One-inch Map (Geological Survey) in which they occur, with the number of the corresponding sheet of the New Series Map in square brackets, and the title of the corresponding Geological Survey Memoir. A key-map is appended (Plate 4).

The summary may not be exhaustive, but it serves to illustrate the conditions obtaining throughout the greater part of Northumberland. Most of the ore-bodies occur in the Upper Bernician.

Sheet 110 *S.E.* [4] *and "The Geology of Belford, Holy Island, and the Farne Islands, Northumberland," Mem. Geol. Surv.*, 1900.

The occurrence of lead-ore was recorded as far back as 1814 by Winch, who says "Strings of ore have also been discovered on the coast of Northumberland at Elwick, nearly opposite to Holy Island (1) and on the eastern side of the Island itself."[1]

The following passage is quoted from p. 116 of the Memoir: "Fine large pieces of galena were found north of the Coal Burn and west of the road leading from Hetton Coal Houses to Lowick (2). . . . At the south end of Staples Island (The Farnes) and in the Whin Sill (3) there is a small vein of galena trending N. 32° W., and there is also a vein of galena at Beadnell on the foreshore to the north of the Whin Dyke there (4) and between Limestones No. 3 and 4, from which lead-ore is said to have been got. It runs nearly due north."

Sheet 109 *N.W.* [6].

Strings of lead-ore have been found in the eastern part of the area. A vein was discovered in a small colliery between Rock Hall and Rock Moor House (5) during the 18th Century, and a report on it by William Westgarth in 1767 was given by the Rev. R. W. Bosanquet in 1869.[2] The vein is vaguely described as of tolerable strength, running nearly south-west to north-east, and as having been found in working the coal upon a bed of hazle (sandstone). The ore is stated to have yielded only ten ounces of lead from sixteen ounces of ore (made perfectly clean and assayed), and scarcely any silver at all. Nevertheless, the report advised Lord Jersey, to whom the estate

[1] *Trans. Geol. Soc.*, Ser. 1, Vol. IV., p. 81.
[2] *Proc. Berwickshire Naturalists' Club*, Vol. VI., 1869, p. 69.

then belonged, to let a lease of the vein for a term of 21 years at one eighth of the ore raised, "well washed and fit for smelting."

Mr. Bosanquet adds that "some parties applied for the lease, and appeared to have agreed in the first instance to the terms above mentioned, but before the work was actually commenced they begged to be relieved of their bargain," and that as far as he knew, nothing further was done in the matter.

George Tate[1] in his "Sketch of the Geology of the Howick Coast" mentions having seen galena in the big fault exposed there (6). A vein outcropping in the vicinity of Little Houghton (7) was tried in the 18th Century, and was described by Wallis,[2] as follows:—

"A string, or small vein, was lately discovered in the middle of the villa of Little Houghton: the ore, lodged in coarse spar, talc, and ordinary marcasite, found near the day: in good esteem and was worked by the owner, Mr. Henry Penreth, merchant of Newcastle, for some time, but discontinued after a few trials."

One or more metalliferous strings have been encountered in working the Shilbottle Seam in Shilbottle Colliery (8) and were tried, but unsuccessfully, in the adjacent strata. The Rev. William Nall, who furnishes this information, found specimens of associated galena and blende in a load of coal obtained from that colliery. Two of these indicate a vein 2 or 3 ins. in thickness; in one calcite is present, and in the other quartz and some calcite. The blende is in the form of strings, up to half an inch in width, enclosed within the other minerals.

Sheet 108 *N.E.* [5] *and "The Geology of the Cheviot Hills," Mem. Geol. Surv.*, 1888.

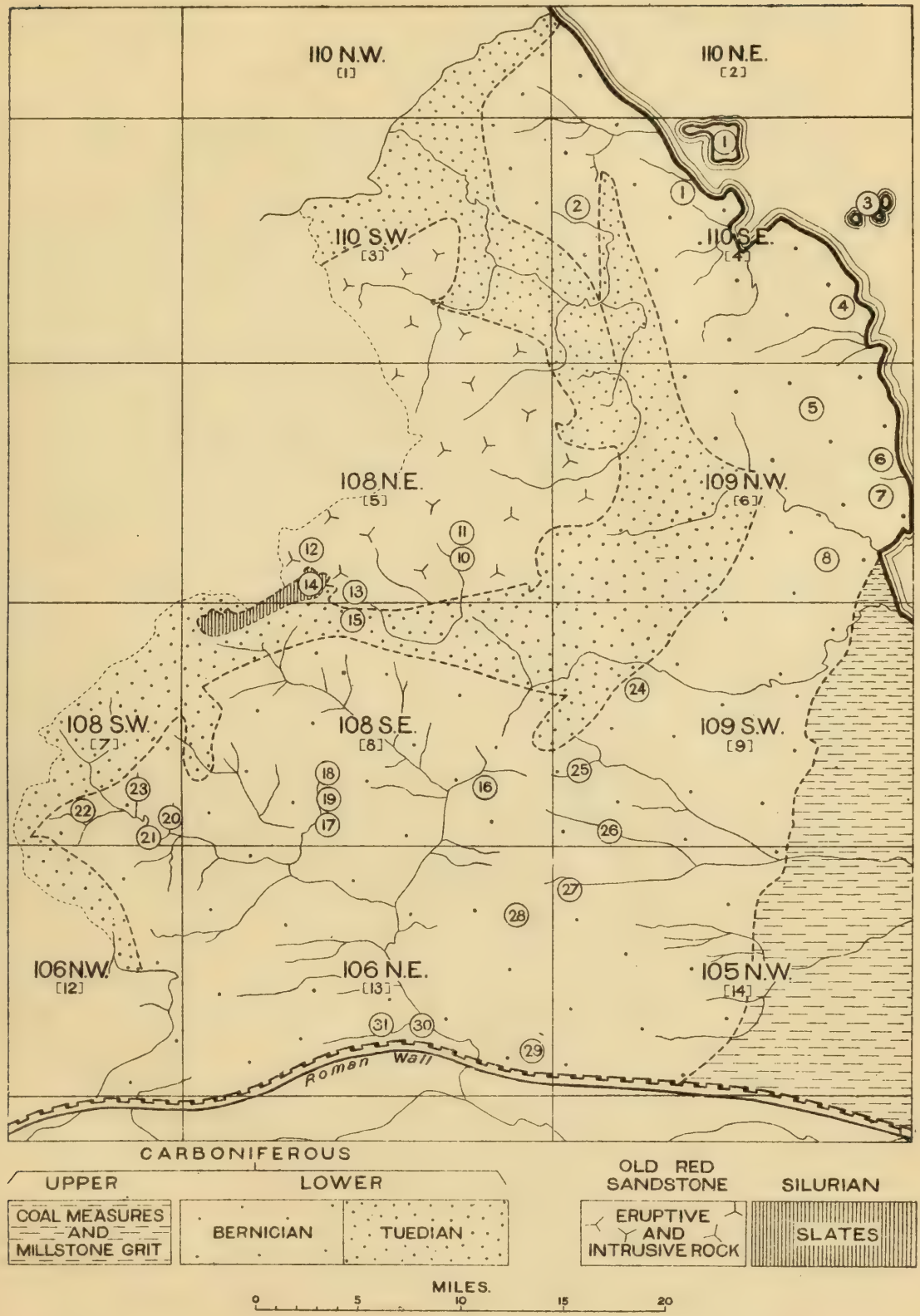
The following occurrences of galena and blende within the area are mentioned on p. 33 of the Memoir.

In the Cheviot Lavas, on the north side of the Cheviots, "in the burn a quarter of a mile S.S.W. of Langlee, there is a strong vein with calcite- and quartz-breccias running slightly E. of N. Within them are strings of the compact green carbonate of copper (malachite), varying in thickness from one-tenth to half an inch" (9).

On the south side of the Cheviots a vein consisting of "various ribs from 1 to 4 ins. thick, composed of calcite mixed with angular pieces of porphyrite, &c., and here and there spotted with small crystals of galena and iron pyrites." This was seen in a craggy glen (Raven's Crag) on the south side of Allerhope Burn, a little over $\frac{1}{2}$ mile above its foot (10); also

[1] *Ibid.*, Vol. III., 1852, p. 100.

[2] "The Natural History and Antiquities of Northumberland, &c.," 1769, Vol. I., p. 121.



AREA NORTH OF THE ROMAN WALL SHOWING 1" MAPS AND LOCALITIES REFERRED TO IN THE TEXT.

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a similar vein (direction uncertain), ½ mile N.N.E. of Raven's Crag (11).

A wide vein contains small specimens of galena associated with calcite, south of Yearning Hall (12).

In the Silurian Inlier some strings of blende occur in the shales and greywacke (14).

Barytes is mentioned as not uncommon near the south edge of the map, but never occurring in large quantity.

Sheet 108 *S.E.* [8] "*The Geology of the Country around Otterburn and Elsdon*," *Mem. Geol. Surv.*, 1887.

It appears from the Memoir (p. 124) that attempts to find lead-ore in workable quantities have failed. Mention, however, is made of strings of calcite carrying some galena in association with the fault bounding the Cheviot Lavas in Ridlees Burn on Heathery Hill (15), *i.e.*, in the same district as the strings previously recorded ; also of strings of calcite containing strips of galena in a limestone in Mill Burn, S.E. from Elsdon (16), and of trials in small veins within the vicinity of High Green, namely, by the side of the High Green Basalt Dyke in the Tarret Burn (17), near the head of Smithy Cleugh (18), and at Hollinhead (19). These occurrences lie a little above the base of the Upper Bernician.

Sheet 108 *S.W.* [7] *and* "*The Geology of Plashetts and Kielder*," *Mem. Geol. Surv.*, 1889.

On p. 25 of the Memoir it is stated that lead-ore had been recorded in the Belling Burn a little above the Railway (20) by Nicholas Wood[1]; near Holy Well a quarter of a mile E.N.E. of Otterstone Lee (21) by the Rev. John Hodgson[2]; in Oakenshaw Burn about 300 yards above the house (22) by shepherds.

Blende occurs in small crystals in a fault-breccia in Plashetts Burn (23), and as scattered crystals up to ¼ inch in length in calcite strings in Oakenshaw Burn.

Sheet 109 *S.W.* [9].

Lead-ore has been worked on the northern slope of Simonside, S.W. of Rothbury, also near Redpath in Rothbury Forest, and has been tried at Hartington in the south-western corner of the sheet.

The Simonside workings (24) are situated on the northern slope above Whitton Dene, in the Tuedian strata. According to information supplied by Mr. D. D. Dixon, of Cragside, the ore was obtained by a drift into the hillside, where large heaps of debris are still to be seen. It is reported by old residents that Sir Edward Blackett, who owned the estate, worked the mine himself in the 18th Century, but that the ore contained so

[1] Map accompanying paper in *Trans. N.* of *Eng. Inst. Min.* and *Mech. Eng.*, 1862, Vol. XI., pp. 101–137.

[2] "Memoir of the Rev. John Hodgson," Vol. I., p. 146.

little silver that it did not pay. W. Topley, however, states that the mine never yielded much ore.[1]

There are several shallow circular holes in the hill which Topley regarded as traces of early lead-mines, and in these pieces of galena are still to be found. It may be remarked that Tosson, where the swords mentioned on p. 7 were found, lies in the immediate neighbourhood.

The Redpath Mine (25) is situated on the Fallowlees Burn in Rothbury Forest, south of Simonside.

The vein, which trends nearly north-and-south, is exposed, and has been worked on the east side of Jock's Nowe, a triangular outcrop of limestone some 150 yards in length, with the stream running on its eastern and southern sides, and an old forsaken channel defining it on the west. It was reported on by George Henderson about 1852 and a large quantity of lead-ore is said to have been obtained at the surface, both from the vein and in the form of large loose pieces. A number of east-and-west strings (character not mentioned) are stated to cross the burn near the vein. North of the Nowe the vein has not been found, although two drifts have been driven in search of it. On the south side of the stream it has been followed for some distance but has proved unproductive, though a string carrying a ribbon of galena, 1 in. in width but diminishing southwards, was cut about 2 ft. away from the cheek.

Topley[2] states that the vein has yielded a good deal of ore, but the report does not convey this impression. The mine, however, is old, for it was mentioned by John Wallis[3] in 1769.

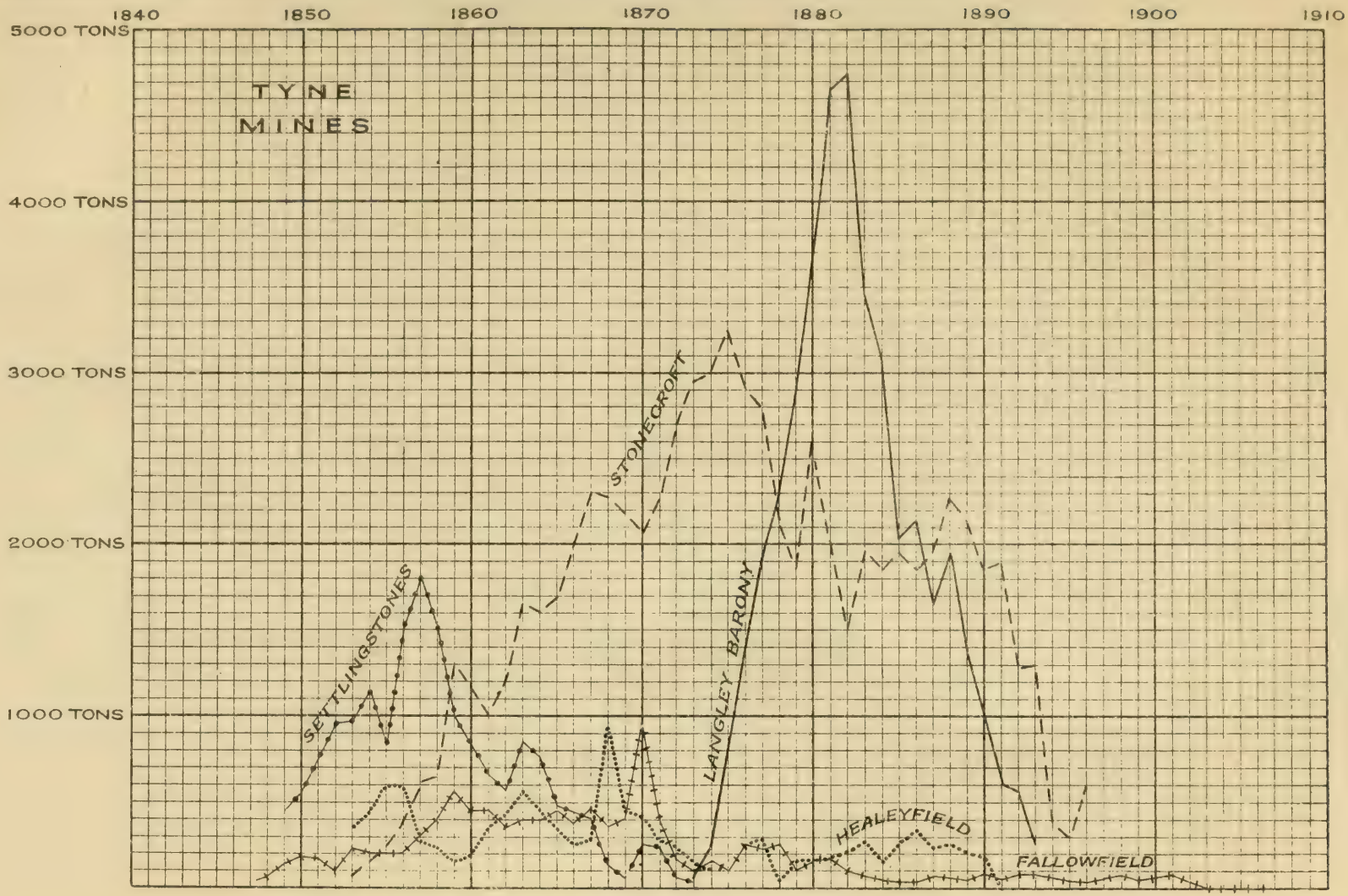
According to the information gathered by George Henderson, a vein "bearing about N. 76° E. Magnetic Meridian" was cut early last century, in process of draining on Hartington Farm in the immediate vicinity of the village (26). Some ore was obtained, and the farmer upon whose land the discovery was made stated that one piece of solid ore weighted $2\frac{1}{2}$ cwts. A shaft was thereupon sunk to a depth of 4 or 5 fthms. and the vein opened for some 10 or 12 yards eastwards, but the owner of the land would not permit further development.

Some 30 years later, at the time the report was written, another shaft was sunk to the same depth as the first, and a level was driven from this to the foot of the earlier one, but no ore was obtained. Mr. Henderson states that he was not able to see the vein itself, but that the stratum on both sides of it appeared to be "whin" and the matrix calcite. He was told that there was a "good mine" left standing in the eastern forehead.

Sheet 105 *N.W.* [14].

Trials for a lead-mine were made during the early part of the 19th century at the side of the Wansbeck near to the

[1] "Guide to Rothbury," 1885, p. 51.
[2] *Ibid.*
[3] *Op. cit.* Vol. I., p. 121.



OUTPUTS OF GALENA FROM MINES IN THE LOWER TYNE AREA.

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village of Kirkwhelpington (27), where some ore had been seen as a vein or in strings traversing a limestone immediately above the Whin Sill.

The lode was sought by means of both shafts and drifts, and the explorations were freed of water by means of a water-wheel, but the enterprise achieved no success.[1]

Sheet 106 *N.E.* [13].

The following mines and trials occur north of the Roman Wall:—

Quarryhouse Lead Mine (28) is situated near Thockrington, some 4 miles south of Knowesgate Railway Station. The vein and mine are described in a report made by G. A. Lebour in 1873, and in a letter written by Thomas Stokoe to George Henderson in 1852. The vein runs N.N.E.–S.S.W. with no appreciable hade, and varies in width from a few inches to 2 feet, but there are indications of strings branching from the main lode. The vein-mineral in calcite. Mr. Stokoe in his letter records that the vein, as seen in the engine-shaft, was "1 foot wide in a rib of solid ore for 3 yards deep in the Whin above the Limestone."

Lebour states that the lode is visible in the roof and at the extremities of the levels, and lead can be obtained from almost every part of these old workings, but more especially in the upper part. The poorer part of the vein is in the bottom level, but nowhere was ore entirely absent.

Three shafts are sunk upon the lode and pass through the Whin Sill into the limestone and shales beneath it, and the pumping and winding shafts, which are close together, penetrate to a depth of between 20 and 30 fthms. Three levels are stated to have been driven in the vein, and two others are mentioned (one above these and the other below them), but no further information concerning them is supplied. Two cross-cuts have been made from the top level.

The official mining statistics include no returns from this mine, yet a statement was obtained from an old workman that he carted ore from the mine to the railway station as a youth.

A trial for the Fallowfield Vein near Grottington (29) is described in conjunction with the Fallowfield Mine (p. 21, &c.).

There are faint indications of mining operations near Sharpley, a farmstead $\frac{3}{4}$-mile S.S.E. of Simonburn and $\frac{1}{2}$-mile north of the Roman Wall (30). Wallis mentions that a mine "was opened some years ago at Sharpley near Simonburn by Sir Lancelot Allgood, of Nunwick, Knt.—the ore good, but not in sufficient quantity to continue working it." He also states "there was lately a boring for lead ore at Overton near Simon-

[1] These particulars are taken from the report by George Henderson. "An Account of the Strata of Northumberland and Durham as proved by Borings and Sinkings," 1885, Vol. III., p. 321, includes a section of one of the shafts, which is there stated as having been sunk in 1829.

burn on the estate of Sir Ralph Milbank, of Hannaby, Bart., but it was found not to answer the expense of working."[1]

THE LOWER TYNE AREA.

This narrow belt of metalliferous country, separated from the extensive lead-bearing region to the south by an unproductive zone, stretches along the northern side of the Tyne from Thornbrough, east of Corbridge, to where, at a point 2½ miles west of Haydon Bridge, that river is joined by the Allen. It may be said to have a length of 14 and a breadth of 3 miles.

Except the Morralee Veins, which lie between the Allen and the Tyne, no profitable veins appear to have been discovered on the south side of the river. Several trials have been made, but without success. An attempt, for instance, was made to work a lead-vein at Hallstock Dene, in Dilston Park, as far back as 1734.[2]

Most of the veins trend N.E.–S.W. and in every case where information has been obtainable they carry sulphate or carbonate of barium. Blende occurs only in inappreciable amount. The galena is poor in silver.

The Upper Bernician sequence can be divided into three divisions. The approximate thicknesses of these, and the principal limestones they contain, in and immediately to the north of the Tyne Valley, are shown in the following Table:—

	Approximate thickness in Feet.[3]
The Upper Division:—	
Beds above the Great Limestone, including—	
The Fell Top Limestone. (20 ft. at Harlow Hill)	1,000 to 1,200
The Robsheugh Limestone. (16 ft. at Robsheugh)	
The Thornbrough Limestone. (18 ft. at Thornbrough)	
The Corbridge Limestone. (16 ft. average)	
The Little Limestone. (16 ft. average)	
The Middle Division:—	
The Great Limestone. (50 ft. very constant)	500
The Four Fathoms Limestone. (25 ft. average)	
The Three Yards Limestone. (12 ft. average)	
The Five Yards Limestone. (15 ft. average)	
The Scar Limestone. (12 ft. average)	
The Lower Division:—	
About 12 thin but persistent limestones, ranging up to 10 or 12 ft. or more in thickness, including at the base of the series:—	1,200
The Fourlaws Limestone. (12 ft.)	
The Redesdale Limestone. (17 ft.)	

[1] *Op. cit.*, Vol. I., pp. 121, 122.

[2] Greenwich Hospital Law Papers, No. 14. *See* "A History of Northumberland," Vol. X., 1914, p. 334.

[3] The thicknesses are chiefly based on measurements made in the field. *See* Stanley Smith, "The Faunal Succession of the Upper Bernician," *Trans. Nat. Hist. Soc., Northumberland, Durham, and Newcastle-upon-Tyne*, 1910, New Series, Vol. III., pp. 591–645.

The Upper and Middle Divisions are exposed south of the Roman Wall and the Lower Division on the north side. The list takes no account of the thin and less persistent beds, or the numerous calcareous shales. Except locally the sandstones have not received distinctive names as they have in the districts of the main metalliferous region. The whole series appears to vary more than the corresponding beds in Allendale and around Alston.

The strata in which the veins have been wrought range downwards from the Thornbrough Limestone to the Whin Sill, here lying beneath the Scar Limestone.

The geological structure is complicated by the presence of a N.W.–S.E. anticlinal axis, by which the lowest beds are brought up into the mines near the middle of the belt.

The following is a list of the mines, beginning with the most easterly. None are now raising lead:—

Thornbrough, Fallowfield, Stonecroft, Settlingstones, Langley Barony, Sillyburn, Morralee.

There were formerly smelting mills in this small mining field. The small Fallowfield Mill, connected with Fallowfield Mine, was in existence only for a short time. It closed about 1847. Langley Mill, situated on the south side of the Tyne above Langley Castle, 2 miles S.S.W. of Haydon Bridge, was the largest lead-works in the northern mining-field. It was built by the Greenwich Hospital about 1767, and from 1768 until 1833 was used chiefly for smelting duty ore. Onwards from 1833 it was leased to a succession of lead-smelting firms until it was closed in 1887. Zinc was also smelted at this mill, though only for a short period. Sopwith[1] states: "In 1817 a company took part of Langley Mills, chiefly erected for their accommodation, for the purpose of smelting the ores of zinc, which are found in abundance in some of the Alston veins. These works were successfully prosecuted for a few years; but the price suddenly falling from £70 to £40 per ton, the concern became a losing speculation, and was forthwith abandoned."

It was at this mill that Pattinson developed his processes for the desilverization of lead.

A diagram showing the outputs from the leading mines of the Lower Tyne Area is appended (Plate 5).

Thornbrough Mine.

(*Disused.*)

Maps.—One-in. (Geological), Old Series, Sheet 105 S.W. New Series, Sheet 20. Six-in. (Geological), Northumberland Sheet 95 N.W.

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[1] "An Account of the Mining Districts of Alston Moor," &c., 1833, pp. 124–5.

Site.—Near Thornbrough Kiln House, 1½ miles E.N.E. of Corbridge. By road it is 2½ miles distant from that town, and 3 miles from Corbridge Railway Station.

The Thornbrough Lode is the first of the lead-veins encountered upon leaving the coalfield. It occupies a fault which at Thornbrough runs N.E.–S.W., and has but small displacement, though it probably represents the eastern termination of the "Stublick Dyke." If this interpretation is correct, that great east-and-west dislocation must swerve round into a more northerly direction south of Dilston. At Thornbrough, and again near High Town, a farmstead ½ mile S.E. of Dilston, the fault is occupied by a basaltic intrusion. The surface at Thornbrough is occupied by an extensive outcrop of the Thornbrough Limestone, and it is within this bed and the adjacent strata that the lead has been sought. The Thornbrough Limestone lies at least 600 ft. above the Great Limestone.

Although a small amount of ore has actually been raised at Thornbrough, the mine can only be regarded as a series of unprofitable trials; the workings are neither extensive nor deep. A level has been driven for about a quarter of a mile in a N.E. direction from Thornbrough Kiln House, and a lower (and longer?) one from the side of the stream. Of the three shafts sunk upon the vein the deepest is only 16 fthms.

Mackenzie[2] states that "In 1801, a Company of adventurers made a trial at this place for a lead mine. They procured some good ore; but appearances not being very flattering, they abandoned the enterprise: but this circumstance is chiefly remarkable from the workmen coming into old workings which proved that a lead mine has been wrought here at some very distant period."

The Thornbrough Mining Company took out a 21 years' lease in 1872 and again opened out the mine, but after struggling on for some years closed down about 1885.

A trial for lead was also made at the top of Aydon Dene about a mile to the N.N.W. of Thornbrough, but at an early date. An old shaft indicates the position of the working; it lies 50 to 100 yards from the end of the lane which leaves the road north of Aydon Village. The circumstances under which this trial was made are narrated by Mackenzie.[2]

"A Country man having ploughed up some lead at Aydon, William Errington, Esq., and a Mr. Sopwith, of Corbridge, made trial for a lead mine in 1742. They sank below the great limestone, but without procuring either lead or coal in quantities sufficient to reimburse them for the expense of experiment."

If the statement is correct the shaft must have been many fathoms deep. It is more probable that it was the Corbridge

[1] "View of the County of Northumberland," 2nd Ed., 1825, Vol. II., p. 348.

[2] *Op. cit.*, p. 346.

Limestone that was penetrated, since that bed outcrops close to the old shaft, though it appears to be cut off to the south by a fault.

Fallowfield Mine.

(Idle.)

Owners.—Messrs. Walton and Cowper, Acomb, Hexham.

Maps.—One-in. (Geological) Old Series, Sheet 106 N.E. New Series, Sheet 13. Six-in. Northumberland, Sheet 85, S.W., S.E.

Site.—On the western side of Red Burn, ¾ mile N. by E. of Acomb, and about 2¼ miles distant by good road from Hexham Railway Station.

History.—Fallowfield Mine is undoubtedly ancient, but the earliest known reference to it is in a document dated 1611, in which John Errington makes petition against Sir John Fenwick who had forcibly dispossessed him of the mine under the pretext that it belonged to the King.[1] The frequent reference to miners to be found in the Register of St. John's Lee testifies to the flourishing condition of the mine during the latter part of the same century.[2]

A report made by a John Armstrong, dated August 14, 1734, indicates that at that time the mine was inundated and idle. A rough plan accompanying it shows a short level 15 fthms. deep running under Acomb Common, and a longer one, described as the Fallowfield Level, 25 fthms. below it. A sump at the south-western end of the "Fallowfield" Level leads to a yet deeper level, and a sump from this to a deeper one still, thus forming as it were, steps. Quoting from the report, "The plan shows how the water falls down two sumps and goes about 1,300 yards in the lowest levels, not passable many years past."[3]

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[1] "State Papers Domestic, Jas. 1," Vol. LXIV., Nos. 45–46.

[2] "A History of Northumberland," 1896, Vol. III., p. 10.

[3] Schemes for draining and extending the mine are suggested and an estimate of costs involved is appended. The information afforded respecting the cost of material and labour in the middle of the 18th century is of interest:—

"A computation of the charges that would carry a drift 25 fathoms deeper through Acomb Fell and sink two courses of sumps at 12½ fathoms each, repairing the old shafts, sludging the levels, &c.

		£	s.	d.
1st.	Wood for timbering the shafts and levels	50	0	0
2nd.	For repairing the shafts sludging the levels	50	0	0
3rd.	A drift from Ramshaw shaft to carry air	20	0	0
4th.	12 Twinheads at 25s. per Twinhead	15	0	0
5th.	6 Sumps at 30s. per fathom depth 12½ fathoms	112	10	0
6th.	6 Sumps below 12½ fathoms each at 30s.	112	10	0
7th.	Driving a drift 180 fathoms at 30s.	270	0	0
		£630	0	0"

A copy or an abstract of a report, dated 1766, shows that improvements on the lines of those suggested in the earlier report had been carried out, and that the mine was then in full operation. In 1765, it states, 1,000 bings (400 tons) of lead were raised, 100 miners were employed, and the working cost of the mine for that year was £5,200.

John Wallis, in "The Natural History and Antiquities of Northumberland," 1769, Vol. I., p. 121, records that "The lead mine at Fallowfield was exceedingly rich for many years till it was drowned . . . It was lately opened and a fire engine erected. It gives employment to about 80 men." The late David Burns, in a report written in 1911, draws attention to this engine, and remarks "This must have been one of Newcomen's or Smeaton's engines, as it was in 1765 that Watt first thought of a separate condenser, and it was in 1769 before he took out his first patent. This shows the mine to have been in the hands of an enterprising capitalist who knew its value, as the fire engine would be a great and expensive innovation both to install and maintain."

A plan dated 1799 shows that the vein had been extensively explored by the end of the 18th century. The North Tyne Level, the Acomb Flank Level, and the Engine Flank Level had already been constructed and a large number of shafts had been sunk.

Messrs. Jacob Walton and John Cowper took over the mine in 1845, and it has remained in the possession of their families up to the present time. Mr. Walton, upon acquiring it, established a market for the witherite, and in so doing opened out one of the earliest, if not actually the first, barytes mines in the country. To its close it remained one of the two chief sources of witherite within the British Isles. The underground workings were closed in 1908 but surface-work continued until 1914.

Geology.—The Little Limestone outcrops on the north side of the vein, whilst on the opposite side the Oakwood Coal comes to the surface and was reached at 30 ft. depth in the Old Engine Shaft. Thus the Great Limestone is reached at about 40 fthms. on the one side but at 80 to 90 on the other.

The section of strata as proved in the various shafts may be given as follows :—

Strata sunk through at Fallowfield.

	Fms.	Ft.	Ins.
Soil, &c.	6	0	0
Plate and coal 2 ins.	0	3	0
Plate and grey beds	6	3	0
Bastard limestone	0	1	0
Grey beds and plate	1	5	0
Limestone	0	2	0
Hazle and girdles	0	4	6
Coal, OAKWOOD SEAM	0	1	6
Sandstone	1	1	2

	Fms.	Ft.	Ins.
Grey beds, plate and ironstone	4	1	0
Sandstone	0	3	0
Grey beds, plate and coal 4 ins.	0	3	10
Strong grey beds	0	5	0
Sandstone	3	1	0
Grey beds	0	3	4
Hazle and sandstone	0	3	6
Grey beds, plate and coal	0	2	8
Coloured sandstone	1	0	5
Plate	0	4	4
Grey beds	0	2	4
Hazle	2	1	2
Dark-coloured mica post	0	2	9
Hazle and sandstone	5	4	0
Strong girdle beds	3	5	10
Plate and grey beds	6	1	0
Hazle	1	4	0
Plate and grey beds	9	3	0
Limestone, LITTLE LIMESTONE	2	5	0
Hazle and grey beds	2	5	0
Coal [LITTLE LIMESTONE COAL]	0	5	8
Grey beds	1	0	4
Hazle	1	0	9
Plate	0	1	0
Dun bastard limestone	2	0	0
Hazle	6	2	0
Light-coloured limestone	1	3	0
Grey beds	0	5	0
Hazle and girdles	10	2	0
Plate	14	2	6
Limestone, GREAT LIMESTONE	6	2	0
Grey beds black-band and coal	2	1	0
Hazle	8	3	0
Plate	12	0	0
Limestone, FOUR-FATHOM LIMESTONE	3	3	4
Coal	0	0	2
Grey beds and coal 6 ins.	2	4	8
White post with coal pipes	0	3	0
Grey beds	1	2	0
Plate	2	2	0
Black-band [splint-coal and ironstone]	0	3	0
Hazle	–	–	–

The Fallowfield Vein trends N.E.–S.W., thus conforming to the general rule, but unlike most of the ore-bearing faults in the region, has a large displacement, throwing down the strata to the south some 40 to 50 fthms. From it three or four South or Sun Veins diverge at small angles.

The vein has been worked from Pit Houses to Codlaw Hill, a distance of not quite 2 miles, and has been followed for a short distance further in both directions by shallow levels. The North Tyne Level, the mouth of which faces Warden Mill on the opposite bank of the river, failed to prove the vein but cut a series of minor faults. Similarly at the other end a trial-shaft was sunk in 1890 to the top of the Little Limestone, $\frac{1}{4}$ mile south of the Military Road, and a short cross-cut made. This again only encountered three small faults, although a little ore was obtained. Whether the vein splays out at these two

points into small faults, or whether the trials were not prosecuted far enough, remains to be tested.

Throughout the workings the vein maintains a thickness of about 20 ft., widening out in some places to 40 ft. It has the unusual inclination of 1 in 5 to 1 in 3, or about 19° from the vertical, and this to the S.E. It is less influenced by the hardness of the strata it traverses than thinner veins are.

The chief vein mineral is witherite, but much barytes also is present as well as a little barytocalcite or alstonite. The galena occurs as ribs and strings, in pockets, or as scattered crystals. The amount of blende is negligible. The workings are not now accessible, but Mr. J. C. P. Walton describes the vein as usually containing two solid ribs of spar with shattered country-rock between them, more or less impregnated with mineral, and as having a wall of dowk, soft earthy extraneous material next to the northern cheek. The galena he considers to be most richly concentrated near the cheeks, perhaps more particularly on the northern side next to the dowk, and sometimes between this and the cheek itself.[1]

A quaint description in the report dated 1766 is considered by Mr. Walton to be a good account. "She is a strong vein, running E. and W., or rather two veins, E. of the engine; against the north cheek is a soft dowk partly shivery, next to that a strong cawk, or spar, a yard or more wide, which is joined on the south side by a strong rider mixed with spar several yards wide, the southmost part of which is all or mostly spar, in which lies ore in ribs of 4, 5, or 6 ins. wide. This spary part is 1½–2 yds. wide, but instead of the rib the spar is sometimes flowered with ore. In some places opposite the little limestone on sun cheek the vein seems to form a sort of flat, and that spary bearing part of the vein flutters in among the riders towards the North cheek."

Mining.—The vein has been extensively worked between the Low Engine[2] and Codlaw Hill Shafts, and a shallow level has followed it westwards from the Low Engine Shaft to the shaft at Pit Houses. The chief levels traversing the vein are those which at the Low or Old Engine Shaft lie 20, 45, 61, and 69 fthms. from the surface. The 20- and 45-fthm. levels extend the whole distance between the two shafts above mentioned; the two lower levels not so far. Access to the workings is gained by means of flank levels and by the numerous shafts.

The Old Engine Shaft is the only one that needs particular mention. It has been carried to a depth of 86 fthms., and from

[1] This account differs somewhat from that given in "Special Reports on the Mineral Resources of Great Britain," *Mem. Geol. Surv.*, Vol. II., 2nd Ed., 1916, p. 10, which speaks of the lead as being concentrated in the middle of the vein.

[2] The Low or Old Engine Shaft lies S. of Halfway House, not 400 yards to the E. as on the published 6-inch Geological Map. The shaft to the E. is the New Engine.

its foot a short level has been driven along the vein. From this a sump leads down 10 fthms. to a still lower and shorter level, and from the floor of this another sump penetrates the vein for another 10 fthms., so that the vein has actually been explored to a depth of 100 fthms. This depth, however, was only reached with difficulty due to water and lack of ventilation, but the vein was proved to a limited extent. Some fairly promising ore was obtained. The vein has also been touched below the 69-fthm. level at the foot of the Lonage Shaft.

The mine is drained by means of the old Acomb level, and little pumping was required. The thickness of ground thus drained increases from 20 fthms. at the Low Engine Shaft to 102 fthms. at the eastern boundary.

The Little Limestone Coal has been wrought on the northern side of the vein, and the coal workings were at one time in communication with those in the vein.

Summary of Output, Fallowfield.

Lead-ore in the years 1848–1907 and 1911 (1904 missing) 60 years	11,196 tons.
Lead in the same years (1884, 1890–1892 and 1904 missing) 56 years	7,959 tons.
Silver in the years 1854–1882 and 1901–1902, 31 years	28,641 ozs.
Metallic lead in ore, calculated on returns for 51 years	73 per cent.
Silver per ton of lead, calculated on returns for 31 years	4 ozs.

Birkey Burn.

Maps.—One-in. (Geological) Old Series, Sheet 106 S.E. New Series, Sheet 19. Six-in. (Geological) Northumberland, Sheet 94 N.W.

Site.—½-mile due south of Fallowfield Mine.

The Acomb Coal Company's workings in the Little Limestone Coal, which are situated on the south side of Acomb, encountered in the vicinity of Birkey Burn a small series of parallel faults striking N.E.–S.W., with an aggregate downthrow of 80 ft. to the south.

The more northerly and more powerful of these had a throw of 46½ ft. and carried witherite or barytocalcite and some galena. It was tried to a depth of 40 fthms. by two shafts and several drifts. It is reported to have been some 15 ft. wide at the foot of the deep shaft or sump, and, according to a section in the possession of Mr. J. C. P. Walton, splits up into strings as it approaches the surface.

The exploration was prosecuted between 1869 and 1872 by Messrs. Walton and Cowper, but in 1872 an explosion took place, which led to the work being abandoned.

Grottington or Pont Head Mine.

Maps.—One-in. (Geological) Old Series, Sheet 106 N.E. New Series, Sheet 13. Six-in. Northumberland, Sheet 85, N.E.

Site.—$\frac{1}{3}$ mile W. of Grottington, $\frac{1}{2}$ mile N. of Military Road.

A trial was made near Grottington about 1852 in search of the Fallowfield Vein, with a view of working it north of the Fallowfield Royalty. A shaft was sunk on the line of the vein to a depth of 20 fthms. and a number of short levels were driven, and though the Fallowfield Vein does not appear to have been cut, three veins were proved, one striking N.W.–S.E., another due east and west, and a third a little further to the north, trending S. of E.

The first of these is in line with a fault proved in the Stagshaw Bank Colliery to be a downthrow of 8 ft. to the south. The second, from indications on the ground, would seem to pass beneath Grottington farmstead and to cross Watling Street between that colliery and Bewclay.

The strata explored lie above the Great Limestone which outcrops a little to the north of the shaft. A level is described as running under a sandstone 21 yds. in thickness, at a depth of 15 fthms. Some 40 tons of ore are reported to have been raised by 1856 when the venture was abandoned.

Stonecroft and Greyside Mines.

(Disused.)

Maps.—One-in. (Geological) Old Series, Sheet 106 N.E. New Series, Sheet 13. Six-in. Northumberland, Sheet 84, S.E.

Site.—The principal shafts and dressing-floor are situated on Settlingstones Burn, $2\frac{1}{2}$ miles N.W. of Fourstones Railway Station. The road is rough though downhill for half that distance, but is good the rest of the way.

The mines have been worked as a single enterprise and the names Stonecroft and Greyside merely indicate the properties under which the workings have been prosecuted. The former now belongs to Mr. Laidlaw and the latter to the Duke of Northumberland.

History.—The veins were cut in 1851 by Mr. William Benson, and "The Stonecroft & Greyside Mining Company" was formed to work them. The original capital is stated to have been £1,400. Actual production began in 1853 and the mines continued operations until 1896, when ore of an estimated value of £750,000 had been raised.

The development and decline of production are expressed in Plate 5, but it may be added that although Stonecroft was for long the principal producer Greyside raised the most of the ore in the last 15 years.

1853–1860 Greyside raised 1,751 tons out of a total of 4,614 tons.

1861–1870 Greyside raised 8,888 tons out of a total of 18,049 tons.

1871–1880 Greyside raised 3,957 tons out of a total of 26,457 tons.
1881–1890 Greyside raised 16,967 tons out of a total of 19,405 tons.
1891–1896 Greyside raised 4,950 tons out of a total of 5,738 tons.

Just before the closing of the mines the lease was transferred, and the new lessee, having expended much capital to no profit, became bankrupt.

Geology.—These and the Settlingstones Mines are worked in the Scar Limestone and underlying beds, including the Whin Sill, the latter at its greatest thickness (130 feet) with an extensive outcrop north of the mines. The Whin Sill carries the greater part of the lode, the shale below it being barren. The productive strata extended down to 70 fthms.

The veins, four in number, namely the Main Vein, the South or Sun Vein, the South Cross Vein and the North Cross Vein, form a small complex. Their relationship to one another is open to more than one interpretation.

The Main Vein strikes N.E.–S.W. and has been followed eastward from the Stonecroft Shafts for 360 fthms. east of the Greyside Shaft, but the last 100 fthms. are reported to have been barren. Attempts to prove the vein east of Stonecroft have not been successful.

The South or Sun Vein runs due east from the Stonecroft Shafts to Greyside Air Shaft and there unites with the South Cross Vein; it then takes a more southerly direction towards Maughan's Shaft and has been explored for 25 fthms. beyond this shaft, although it has not been found productive for more than 170 fthms. east of Greyside Air Shaft. It may persist farther, for traces of lead-ore have been found in St. Peter's Churchyard (Newbrough) and also in the Fourstones Colliery situated on the south side of the Tyne, in a fault bearing in the same direction as the vein.

Near the Stonecroft Shafts the Main Vein and South Vein either come together and again separate, or they cross. Assuming the former interpretation to be correct, then the Main Vein apparently splits up west of the point of junction, and the South Vein passes into the Settlingstones property.

The South Cross Vein and the North Cross Vein are evidently one and the same lode, slightly dislocated by the Main Vein. They run exactly in the same direction, but not precisely along the same line. The South Cross Vein, on splitting off from the South Vein at Greyside Air Shaft, runs north-west into the Main Vein, and the North Cross Vein lies on the north side of it.

The Main Vein is nearly vertical, but hades slightly to the south; the downthrow is in the same direction as the hade, and is about 100 ft. The Sun Vein hades a little more steeply, but

has the same direction and a displacement of about 90 ft. The two Cross Veins are reported to have a small downthrow of 5 or 6 ft. only to the west.

The principal mineral these veins carry is barytes, but a little witherite is also present. They have proved exceptionally rich in galena, and the richest section is stated to have been the region of union between the Main and South Veins.

Mining.—The workings lie wholly within the Whin Sill, or have that rock as one of the cheeks to the vein.

Entrance into the mines was mainly by shaft, although there is an adit-level at Stonecroft. The Stonecroft winding and pumping shafts reach a depth of rather more than 60 fthms., and are situated near the junction of the Main and South Veins. The Greyside Shaft was sunk upon the Main Vein to a depth of 70 fthms. some 200 fthms. east of the Stonecroft Shafts.

The Greyside Air Shaft at the union of the South and South Cross Veins is 75 fthms. deep, and Maughan's Shaft, 250 fthms. further east upon the South Vein, is 46 fthms. deep. The levels are named according to their depth in the Stonecroft Shafts.

Main Vein:—

Adit-Level, 12 fthms. deep, at the Stonecroft Shafts.
15-fthms. Level runs from Stonecroft Shafts to 360 fthms. east of Greyside Shaft.
30-fthms. Level runs from Stonecroft Shafts to 24 fthms. east of Greyside Shaft.
45-fthms. Level runs from Stonecroft Shafts to 100 fthms. east of Greyside Shaft, and also follows the vein 100 fthms. west of Stonecroft.
50 and 55-fthms. Levels, short levels running eastwards from Stonecroft Shafts.

South or Sun Vein:—

15-fthms. Level, a short level driven eastward from the Stonecroft Shafts.
30-fthms. Level runs from Stonecroft Shafts to 200 fthms. east of Greyside Air Shaft.
45-fthms. Level runs from Stonecroft Shafts to Maughan's Shaft.
50-fthms. Level runs from a point rather more than 100 fthms. west of Greyside Air Shaft to 25 fthms. east of Maughan's Shaft.
60 and 69-fthms. Levels, short levels driven east and west from Greyside Air Shaft.

The South Cross Vein and the North Cross Vein have not been so extensively worked, although they have been opened out to the depth of the 45-fthms. Level. The Sun Vein has only been followed for about 160 fthms. from the Main Vein.

Summary of Returns.

Lead-ore, 1853–1896 (44 years)	74,264 tons.
Lead, 1853–1896 (1870, 1884–1885, and 1890–1892 missing), 38 years	48,269 tons.
Silver, 1854–1882 (1870 missing), 28 years	95,272 ozs.
Metallic lead in ore	75 per cent.
Silver per ton of lead	2·45 ozs.

Settlingstones Mine.

(Disused for Lead.)

Maps.—One-in. (Geological) Old Series, Sheet 106 N.E. New Series, Sheet 13. Six-in. Northumberland, 84 S.E., S.W.).

Site.—The mine lies 3 miles to the north of Haydon Bridge village, and the same distance from Fourstones Railway Station.

History.—About 1690 rent for the mine was being paid to Mr. John Fenwick of Morpeth. Notices advertising its sale were published in the Newcastle Courant in 1743, and again in 1773.[1] It passed into the hands of Mr. Frederick Hall early in the 19th century, and has remained in the possession of the family, although the enterprise was converted into a Company under the title of "The Owners of Settlingstones Mines, Limited," in 1907. The mine ceased to raise lead in 1873, but began its important career as a barytes mine in 1872.

Geology.—The strata through which the vein has been worked are shown by the following section of the Pumping Shaft. The depth to which the vein carries lead yet remains to be proved; the workings do not descend far below the Whin Sill.

Settlingstones Pumping Shaft.

	Fms.	Ft.	Ins.
Boulder clay	15	0	0
Plate	2	1	6
Limestone [SCAR LIMESTONE]	1	5	0
Whetstone (indurated sandstone)	2	1	0
Whin Sill (dolerite)	21	2	6
Whetstone	5	0	0
Plate	5	4	0
Freestone	1	4	0
Limestone-plate	0	5	0
Plate	1	0	0
Limestone	2	1	0
Freestone and grey beds	1	3	0
Plate	1	3	0
Limestone	0	3	0
Post and grey beds	2	0	0
Plate and grey beds	4	3	0
Coal	0	1	0
Post and grey beds	2	2	0
Limestone	1	0	0
Post and grey beds	2	0	0

Settlingstones Main Vein runs N.E.–S.W., and has been proved for a distance of about $1\frac{1}{2}$ miles, from a point a little beyond the N.E. boundary of the Royalty to Grindon Common (*see* Plate 6). It has been sought but not found in the Stonecroft property, and appears to break up east of the boundary. It

[1] Rev. John Hodgson, "History of Northumberland," 1840, Part II., Vol. III., p. 398.

carries galena, however, only in the north-eastern part of the workings for a distance of about ½ mile.

Between the eastern boundary (Plate 6) and a fault N.N.W.–S.S.E. which crosses it some 35 fthms. east of Winter's Shaft, the vein is about 3 ft. in width, is charged with flesh-coloured barytes, and carries galena with some blende. The fault throws down the beds 32 ft. to the west, and displaces the vein 15 fthms. to the north. There is then an interval of barren ground after which the vein widens out to an average breadth of 10 to 12 ft., and holds a remarkably clean and solid deposit of witherite. Another fault crosses the vein a few fathoms west of Frederick shaft, and still further west, 134 fthms. beyond the shaft, a cross-vein (N.E.–S.W.) is encountered, carrying witherite and throwing down to the S.E. Strings branching off from the vein are not infrequent, and some of them bend back into it to form a "horse." The belt of witherite, including masses of country-rock, occasionally attains a width of 40 ft. The vein can be followed the whole way to the level foreheads by means of a joint carrying blende, which rarely attains a thickness of a quarter of an inch, and is sometimes a mere streak. A few tons of galena have been obtained recently in advancing the forehead of the 90-fthm. level.

The vein is almost vertical, having a hade only of 3° or 4° to the south, in the direction of the downthrow. The displacement of the strata effected by it increases westwards; near the N.E. boundary it is only 8 ft., but before the Winter's Shaft Fault is reached it becomes 24 ft.; west of the cross vein it is 84 ft.

The galena is described as having been mainly concentrated in the middle of the barytes, but between the main rib and the cheeks there were parallel strings and aggregations of crystals.

Mining.—The average depth of the lead-workings is about 60 fthms., but by reason of the increasing thickness of superficial deposits and the slope of the ground, the depth is greater at the western than at the eastern end. The depth to the lowest working is 50 fthms. at the boundary and 100 fthms. at the Winter's Shaft Fault that cuts off the galena.

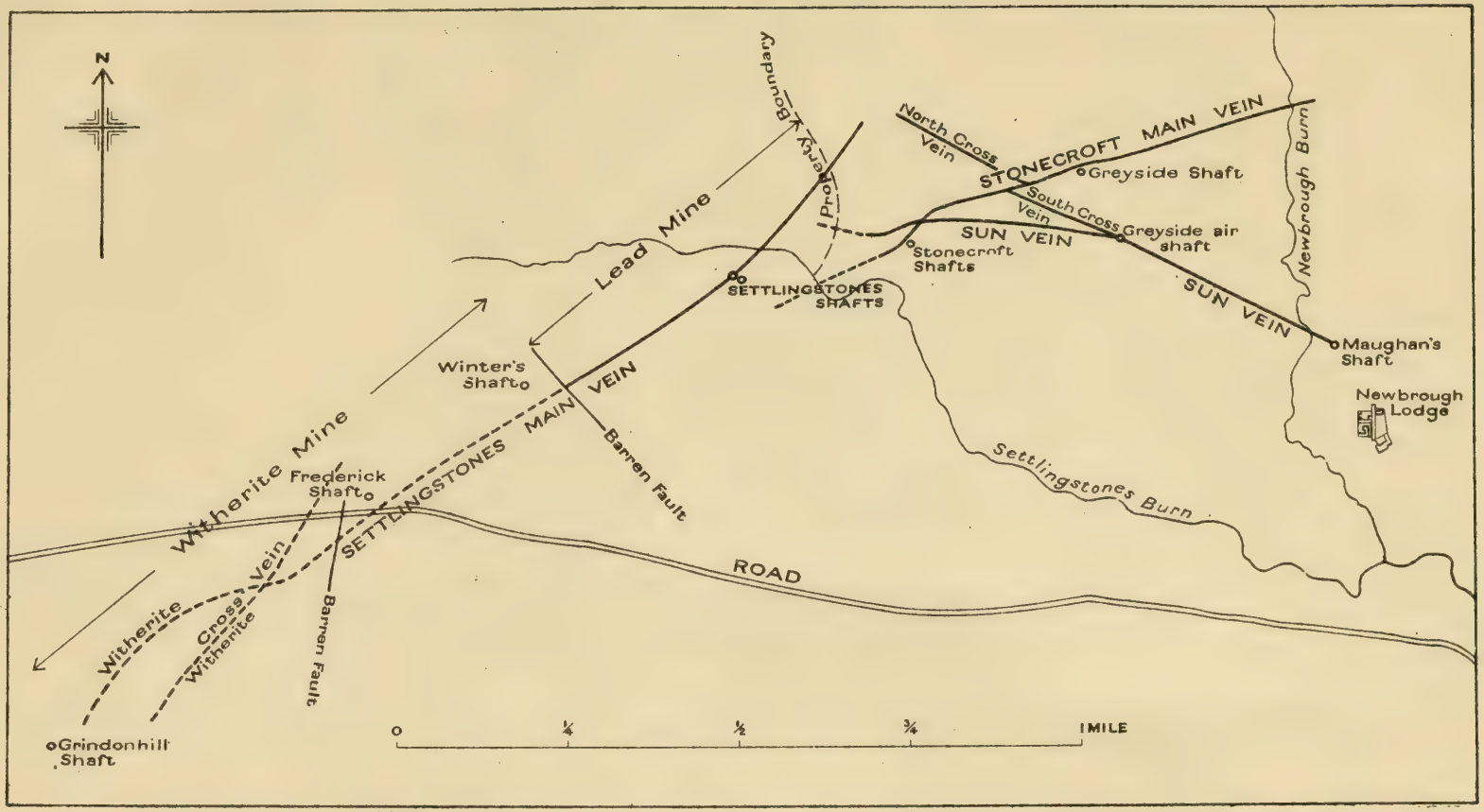
The Pumping and Winding Shafts, 64 and 72 fthms. deep respectively, are situated near the centre of the workings, and from them run seven levels which at the latter shaft lie 13, 28, 36, 44, 52, 60 and 64 fthms. below the surface. The details of these levels are briefly as follows:—

East of the shafts:—

The three higher levels were driven nearly up to the boundary of the Royalty.

The fourth and fifth levels ran about half that distance.

The sixth and seventh levels were not carried forward on this side of the shaft.



PLAN OF THE SETTLINGSTONES AND STONECROFT LODES.

C&R. LTP 746.
1180.6.31/41.750.2/23.

West of the shafts :—

The Top Level was driven wholly in boulder-clay and is only a few fathoms in length ending at a short shaft.

The Second Level was driven in strata, but passed into boulder-clay about half-way between the shafts and the fault that forms the boundary to the workings.

The Third Level has its forehead advanced only a few fathoms beyond the second.

The Fourth Level and those below it, run quite or almost to the fault which brings in the barren ground.

Summary of Returns.

Lead-ore, 1849–1873 (1851 missing) 24 years	16,902 tons.
Lead, 1849–1873 (1851 missing) 24 years	11,835 tons.
Silver, 1854–1873 (1856 and 1858 missing) 18 years	20,348 ozs.
Metallic lead in ore	70 per cent.
Silver, per ton of lead	2·65 ozs.

Langley Barony Mine.

(Disused.)

Maps.—One-in. (Geological) Old Series, Sheet 106 S.E. New Series, Sheet 19. Six-in. Northumberland, Sheet 93 N.W. and 84 S.W. (the latter not geologically coloured).

Site.—On the north side of Honeycrook Burn, 2 miles north of Haydon Bridge Railway Station.

History.—The mine had but a short history, extending over a period of only 20 years. The Bewick Vein was discovered by T. J. Bewick, and a company under the name of "Bewick and Partners" was formed to work it. The statistics show an output of 30 tons in 1873 and a rapid increase to 4,760 tons in 1882, after which it declined as quickly as it rose. In 1893 230 tons were returned, and in that year the mine was closed.

Geology.—The strata traversed by one of the principal shafts are slightly higher than those in the Stonecroft and Settlingstones Mines.

Section of Joicey Shaft.

	Fms.	Ft.	Ins.
Clay and boulders	5	4	7
Plate	0	3	5
Grey beds	3	1	1
Plate	9	3	8
Limestone [FOUR-FATHOM LIMESTONE]	5	2	6
Coal	0	0	8
Seggar	0	2	9
Hazle	1	4	9
Coal	0	0	10
Seggar clay and grey beds	1	2	0
Plate	0	5	4
Grey beds	0	4	5
Plate	0	1	0
Hazle post and grey beds	0	4	3
Hazle	4	5	5

	Fms.	Ft.	Ins.
Plate and grey beds	3	3	4
Hazle	0	5	0
Grey beds	1	4	8
Hazle	0	1	0
Plate	3	2	4
Hazle	0	1	3
Plate	5	4	9
Limestone [THREE-YARDS LIMESTONE]	2	1	9
Coal	0	0	9
Seggar clay	0	2	3
Coal	0	1	2
Seggar clay	0	5	0
Plate	1	1	6
Coal	0	1	0
Hazle	5	2	4
Plate	2	5	0
Limestone [FIVE-YARDS LIMESTONE]	1	0	0
Plate	0	5	9
Hazle	1	1	6
Plate	0	5	9
Limestone	0	1	3
Hazle	1	0	3
Plate	3	3	2
Grey beds	0	4	3
Coal / Plate / Coal	0	3	10
Hazle	0	3	0
Hazle and shale-beds	1	0	3
Grey beds	0	5	3
Hazle	7	4	6
Plate	5	3	0
	90	5	6

Four veins have been proved, all bearing N.E.–S.W., and known from south to north as the Bewick Vein, the Dixon-Brown Vein, the St. Andrew's Vein and the New Vein.

The Bewick Vein has produced most of the ore, and was the only one extensively wrought. It has been opened out for a distance of more than 1,000 fthms. and to a maximum depth of 68 fthms. It may be either a continuation of the Settlingstones Vein or possibly of the Cross Vein that intersects it, but between the Settlingstones and the Langley Barony workings there runs a north-and-south fault. The Bewick Vein is a downthrow south of 7 fthms. at the Joicey Shaft, and of 5 fthms. at the Leadbitter farther west. It is said to have maintained an average thickness of 2 to 4 ft. of compact mineral deposit where traversing harder beds, but to have become less distinct in the softer beds. The mine-section represents the vein as bifurcating in a vertical direction both in the lower part and in the upper part of the workings.

The Dixon-Brown Vein was struck by a cross-cut starting in the Bewick Vein east of the Joicey Shaft, and was worked for 100 yds. or so westwards, but it proved unproductive. Another cross-cut, driven in search of the vein from the adit-level along

a fault, entered much broken ground where the vein was expected; this suggested to the miners a union between the Dixon-Brown and the St. Andrew's Veins.

The St. Andrew's and the New Vein were encountered by other cross-cuts from the Bewick Vein, begun near the Leadbitter Shaft. Both veins were worked westward to their point of junction, a distance of about 150 yds. and a little ore obtained; beyond this the level was continued 350 fthms. along the united veins but in barren ground. The St. Andrew's Vein is reported to be wide and to have a big displacement.

Ribs of solid ore up to several feet in width are reported to have been obtained in the Bewick Vein, but according to a former manager of the mine the average yield was two tons per cubic fthm. Barytes was the principal spar, and flesh-coloured specimens can be seen on the spoil-heaps.

Mining.—Access to the Bewick Vein was by an adit-level and a number of shafts, the most important of which were the Joicey (91 fthms.), of which the section has been given, and the Leadbitter, which is said to have reached the Scar Limestone on the north of the vein at a depth of 76 fthms.

Below the adit-level were four other levels named in relationship to it—the 11-fthms., 27-fthms., 41-fthms., and 57-fthms. levels. The particulars given below have been obtained from the old plans and sections.

Adit and 11-fthms. Levels.—From east of the Joicey Shaft to west of Leadbitter Shaft.

27-fthms. Level.—From the Joicey Shaft to the west of the Brogden Shaft.

41-fthms. Level.—From east of the Joicey Shaft to Brogden Shaft.

57-fthms. Level.—From east of Joicey Shaft to west of Leadbitter Shaft.

The vein has been extensively worked between the adit-level and the 27-fthms. Level, but only in part between the latter and the lowest level.

The St. Andrew's Vein was worked from branches of the 11- and 14-fthms. Levels and in a horizon (or "random") above the former, termed the 4-fthms. Level.

Summary of Returns.

Lead-ore, 1873–1893, 21 years	40,761 tons.
Lead, 1873–1893 (1884–1885, 1890–1892 missing) 16 years	25,116 tons
Silver, 1873–1886 (1874, 1883–4 missing) 11 years	46,671 ozs.
Metallic lead in ore	75 per cent.
Silver per ton of lead	2·3 ozs.

Smaller Mines and Trials in the Neighbourhood of Haydon Bridge.

Attempts to work lead around Haydon Bridge have met with little success, and can be dealt with briefly.

Grindonhill Shaft.

The shaft was sunk to a depth of 50 fthms. on what is presumed to be the Settlingstones Main Vein immediately west of the Settlingstones property. Some ore was obtained but water obstructed development.

Two veins, both bearing N.E.–S.W., have been tried to the south of Settlingstones, namely, the Haydon Fell Vein and the Brokenheugh or Sillyburn Vein. The former is reported to contain barytes only, but the latter carries some ore and was worked in a small way about 1860.

Brokenheugh or Sillyburn Mine.

At this mine, situated 1 mile N.N.E. of Haydon Bridge, the vein has only a small throw and hade to the south, and reaches the surface in the Great Limestone; south of it there is a string which gave rise immediately below the surface to a small flat on its northern side. Little ore appears to have been raised from the vein itself, though a small amount was obtained from the flat, which was worked by means of an open drift. The vein was entered from the south by a level about 80 fthms. in length, and a shaft was sunk in the vein to the level, a distance of 14½ fthms. No independent returns have been made of the ore raised.

West of Langley Barony Mine the Bewick Vein has been worked for a short distance in two places as independent enterprises—at Whinnetley and Waterhouse.

Whinnetley Mine.

The vein was intercepted by a long level driven from the bank of Honeycrook Burn a little to the west of Whinnetley, and was worked eastwards for a distance of 200 fthms. The trial was made about the middle of the 19th century. Returns amounting to 136 tons of lead-ore (102 tons of lead) were made for the years 1858 to 1860.

Waterhouse Mine.

This lies still farther west, where the vein has been wrought from the north bank of the South Tyne for 200 fthms. eastwards. This small mine would seem to be the one mentioned by Mackenzie[1] in 1825 as the Whiteley Well Mine. Returns of 102 tons were made from 1861 to 1865, but this includes the product of Morralee and Howdenside Mines for 1865. In 1880 and 1881 returns of 190 and 280 tons respectively were made. The total amount so returned was therefore 572 tons, yielding 410 tons of lead. The silver-contents of the lead, calculated

[1] "View of the County of Northumberland," Vol. II., p. 304.

upon returns for two years, were 7 ozs. per ton. The vein carries umber or ochre.

Several other trials have been made both to the west and to the north of the mines just mentioned, but none with success.

The foregoing all lie on the northern side of the South Tyne; on the southern side of the river, still farther to the S.W., is the Morralee Mine.

Morralee Mine.

Lies $2\frac{1}{2}$ miles south-west of Haydon Bridge and $\frac{3}{4}$ mile south-west of Water House.

There are here several small faults bearing in the same direction as the Langley Barony Veins, but lying a little south of their range, and they cross the Allen about a mile above its junction with the South Tyne. Lead has been found in one or more of these faults east of Allen, and a level-mouth and shafts mark the site of operations.

Returns of ore were made for the years 1856–64, 1880, and 1881. The production for these 11 years amounted to 119 tons of ore, yielding 86 tons of lead with a silver-content of 7 ozs. per ton.

THE DERWENT VALLEY.

The country drained by the upper part of the River Derwent and Devil's Water constitutes a small mining-field separated by barren ground from the lead-bearing region to the south and west. It extends for about 10 miles from the edge of the coal-field to the head-waters of the Beldon and Knuckton Burns, and has a width not greater than 4 miles. The higher ground is formed of Millstone Grit, but the underlying Carboniferous Limestone sequence has been exposed to view in the valleys.

It is a feature of interest that one of the principal lodes, the Healeyfield Vein, lies within the Millstone Grit. It may also be observed that the Lower Carboniferous strata, in which the rest of the veins run, are markedly more arenaceous than are those in the equivalent part of the succession, either to the west (Allendale) or to the north (The Tyne Valley). This may be seen from the following section proved at Blanchland.

Strata at the Shildon Mine.[1]

	Fms.	Ft.	Ins.
Sandstone, HIPPLE SILL. (About 3 fthoms. beneath Fell Top Limestone) - - - -	7	0	0
Shale - - - - - - - - - -	7	0	0
Sandstone, HIGH GRIT SILL- - - -	8	3	6
Shale, with coal and a bed of sandstone - -	4	5	6

[1] "An account of the Strata of Northumberland and Durham as proved by Borings and Sinkings," *N. of Eng. Inst. Min. and Mech. Eng.*—Supplementary Volume, 1910, pp. 64–5.

The numerous sections of the Shafts at Hunstanworth, given in the same volume on pp. 312–316, are in close agreement with the above.

	Fms.	Ft.	Ins.
Sandstone, LOW GRIT SILL	11	0	6
Shale	1	4	9
"Pebbles" (conglomerate?)	1	0	0
Shale, limestone, and sandstone	1	4	0
Sandstone, CRAG SILL	4	2	0
Shale	4	3	6
Sandstone, PATTINSON'S SILL	6	4	6
Sandstone, "White Sill and Hazle"	6	5	0
Shale	4	0	0
Sandstone	0	3	0
Shale	2	1	0
Sandstone	0	4	0
Shale	5	2	0
Limestone, LITTLE LIMESTONE	2	1	0
Shale and coal	0	5	0
Sandstone, HIGH COAL SILL	1	1	3
Shale	2	0	0
Coal, &c.	0	3	0
Sandstone, LOW COAL SILL	1	2	0
Sandstone, "WHITE SILL"	3	4	0
Grey beds	0	0	8
Shale	1	0	0
Limestone, GREAT LIMESTONE.			

The veins in that part of the valley lying below Blanchland are filled chiefly with barytes, those at and above Blanchland with fluorite. Blende is not abundant.

The following mines are situated in the Derwent Valley :— Healeyfield, Silvertongue, the Edmondbyers, and the Derwent Mines, while within the valley of the Devil's Water, are the Burntshieldhaugh and the Cobbler's Venture Mines.

There were four smelting-mills in the Derwent Valley, namely Healeyfield, Feldon, Acton, and Jeffery's Mills, and on the Devil's Water, Dukesfield Mill.

Healeyfield Mine.

(*Disused.*)

Maps.—One-in. (Geological) Old Series, Sheet 105 S.W. New Series, Sheet 20. Six-in. (Geological) Durham, 18 N.W.

Site.—This mine, only about 3 miles distant from Consett, lies ½ mile west of the village of Castleside.

History.—Healeyfield Mine is undoubtedly ancient, being possibly, as local tradition asserts, of early mediæval date. It belongs to the Dean and Chapter of Durham, and is mentioned by Bailey[1] in 1810 among the mines active at that time.

The Healeyfield Lead Works, Castleside, formerly connected with the mines, were erected in 1805. They are at the present time occupied by Messrs. John Walton & Co. Although no lead-ore has been smelted here since 1913, the mill continues to smelt lead-residues. Parsons and White[2] mention the mill in

[1] "General View of the Agriculture of the County of Durham," p. 37.

[2] "History, Directory, and Gazetteer of the Counties of Durham and Northumberland," Vol. II., p. 181.

1828, and state it was then producing 2,000 bings (800 tons) of lead annually.

Geology.—The vein is a N.N.W.–S.S.E. fracture that is believed to cross both the Ninety-fathom Dyke, 3½ miles north of the Derwent, and another east-and-west master-fault, 1½ miles south of that river. It has, however, been proved to carry ore only south of the Derwent, and for a distance of barely 1½ miles. The dislocation is visible in the river bank.

Between the Derwent and Dean Howl the vein throws down the strata 21 fthms. to the east, and is crossed by a large number of strings. South of this ravine it gives rise to a number of branches, several of which appear to bend back again into the main lode.

The beds within which the lode has been worked belong chiefly to the Millstone Grit sequence, but in part to the Carboniferous Limestone. They comprise alterations of gritty sandstones and shales, the sandstones predominating, as shown in the following generalized section :—

Section at Healeyfield.

	Feet.[1]
Sandstone	—
Shale	15
Sandstone, with shale and "grey beds"	55
Sandstone [HEALEYFIELD FIRESTONE]	25
Shale	25
Grey beds	18
Shale	30
Sandstone	30
Sandstone [LOWER DEAN HOWL FIRESTONE]	45
Shale (Top Level)	10
Sandstone	10
Shale	10
Sandstone	25
Shale	20
Sandstone	25
Shale	10
Sandstone [GRINDSTONE SILL][2]	40
Shale (Derwent Level)	20
Horizon of the Fell Top Limestone.	
Sandstone, shale and grey beds	25
Sandstone	15
Shale	10
Sandstone	10
Shale	40
Sandstone, UPPER SLATE SILL[2]	30
Grey beds	5
Sandstone, LOWER SLATE SILL[2]	25
Shale (Bottom Level)	25

The spoil-heaps consist mainly of rider and country-rock, but the small amount of vein-material present is principally white barytes with some calcite. An old report describes the

[1] Thicknesses are approximate; they have been scaled from the mine-section.

[2] Correlation as given on mine-section, but questionable. The Upper and Lower Slate Sills are generally known in the Derwent Mines as the Upper and Lower Grit Sills.

ore as being much "brangled," and disseminated through the rock.

Mining.—The Engine Shaft is in Dean Howl near Dean Howl House, and was sunk to 60 fthms. There are three important levels, the Top or Horse Level, the Derwent Level, and the Bottom Level. There is still another long level above the Top Level, and a short one interpolated between the Top and the Derwent Levels.

The Top Level has its adit near the Engine Shaft, and has been driven in the vein for 750 fthms. in a southern direction; its forehead stands under a cover of 50 fthms. The Derwent Level was started in the bank of the river, and is nearly a mile in length, its forehead lying 200 fthms. south of Dean Howl and 32 fthms. below the Top Level. It runs by the side of the vein for 200 fthms. before entering it. The Bottom Level was driven south from the foot of the Engine Shaft, 60 fthms. below the Top Level. The levels approximately follow the strike, and each therefore tends to keep in the same bed.

The most extensive workings, according to the mine-section, lay between the Engine Shaft and Fell Shaft, 540 fthms. to the south, between the surface and a depth of about 15 fthms. below the Top Level (*i.e.*, to a depth of 70 fthms. where the cover is greatest). Near the Engine Shaft the vein has been worked at all randoms, but not to any great extent at any one.

Excavations from the Top Level, both by rises and sumps, continue 200 fthms. south of the Fell Shaft, and some work has been done in the Bottom Level near its forehead, 300 fthms. south of the Engine Shaft. The workings in the lower level lie 90 to 100 fthms. below the surface. The section of the vein most vigorously worked was that in which the branching takes place.

According to a report by Mr. John P. Walton, the principal ore-bearing sill was the Lower Dean Howl Firestone; this lies above the Top Level on the western side of the vein, and below it on the eastern side.

Most of the workings were efficiently drained by the Derwent Level.

Ruins of extensive mine-plant (bouse teams, dressing floors, &c.) are to be seen in Dean Howl, but ore was also at one period dressed on floors situated near the mouth of the Derwent Level.

Summary of Returns.

Lead-ore, 1853–1891[1] (1875 missing), 38 years	10,490 tons.
Lead, 1853–1891 (1875, 1884, and 1885 missing), 36 years	6,787 tons.
Silver, 1853–1890 (1875 and 1884 missing), 36 years	108,336 ozs.
Metallic lead in lead-ore	67·5 per cent.
Silver per ton of lead	15 ozs.

[1] Returns for 1860 and 1862 are stated as Healeyfield and Beldon.

Silvertongue Mine.

(Disused.)

Maps.—One-in. (Geological) Old Series, Sheet 105 S.W. New Series, Sheet 20. Six-in. (Geological) Northumberland, Sheet 109 S.E.

Site.—On the north side of the Derwent, ¾ mile west of Healeyfield Mine.

Geology, &c.—The strata, in which the veins outcrop, belong to the highest part of the Carboniferous Limestone Series, and include the Fell Top Limestone. According to the information recorded on the maps of the Geological Survey, which is practically all that is available, there are three veins converging within the narrow tongue of ground enclosed by a bend of the river, Old Silvertongue Vein ranging N.–S., Middle Vein ranging N. by W.–S. by E., and another to the west of these, ranging N.W.–S.E.[1]

The Old Silvertongue Vein throws down to the west, the amount of displacement increasing southwards from 9 to 18 ft., whilst the Middle Vein has a downthrow to the east of 12 ft. at the river. This vein has been traced for a short distance beyond the Derwent.

The veins carry barytes, very white samples of which can be picked up from the old spoil-heaps, but from all accounts were not very productive of galena. The lead, however, is credited with having contained 30 ozs. of silver per ton.

A drift and three shafts gave access to the mine but no details could be obtained concerning the workings. The mine can only have been operative for a short period; no mention is made of it by Parsons and White in 1828, and it is stated to have ceased operations about 1850. Hunt's Stratigraphical Tables include only one return, namely, 138 tons of ore for the year 1848.

Near Hisehope Burn on Muggleswick Common galena has been observed as small strings in the Millstone Grit. It is not likely that it will be found in more than traces.

EDMONDBYERS MINES.

Swandale, Burnhope, and Harehope Gill Mines.

(All disused.)

Maps.—One-in. (Geological) Old Series, Sheet 105 S.W. New Series, Sheet 20. Six-in. (Geological) Durham, Sheet 17 N.W.

Site.—The three mines stand on a lode which may be called the Swandale Vein, within a distance of little more than ½ mile above the village of Edmondbyers; the mines are

[1] This vein is recorded on the 1-in. map only.

close to the road, but are 7 miles from Stanhope Station and a little more from Blackhill. The vein strikes N.W.–S.E., and appears to have determined the course of the Swandale and Harehope Burns which enter the Burnhope Burn almost at the same point. It runs by the side of the sike carved by the former, but along the ravine excavated by the latter.

The strata penetrated by the workings belong to the uppermost part of the Carboniferous Series. The Harehope Gill Shaft enters them above the Fell Top Limestone, but the Swandale and Burnhope Shafts below that bed. According to the mine-section the following sequence occurred :—

Swandale Shaft.

Boulder clay		12 ft.
Shale		50 ,,
Sandstone—GRIT SILL		50 ,,
Shale		15 ,,
Sandstone—CRAG SILL		24 ,,
Shale		18 ,,
Sandstone—PATTINSON'S SILL		29 ,,
Shale	to a depth of	12 ,,

The correlation of the sills may be assumed to be correct.

The vein is reported to vary in thickness from a few inches to 5 ft., but neither the amount nor the direction of displacement is known. Judged by the spoil-heaps, the principal spar is barytes, white samples of which were collected. The heaps contain also calcite and much ferruginous mineral containing a little zinc blende. The three mines were worked by independent companies.

Swandale Mine.

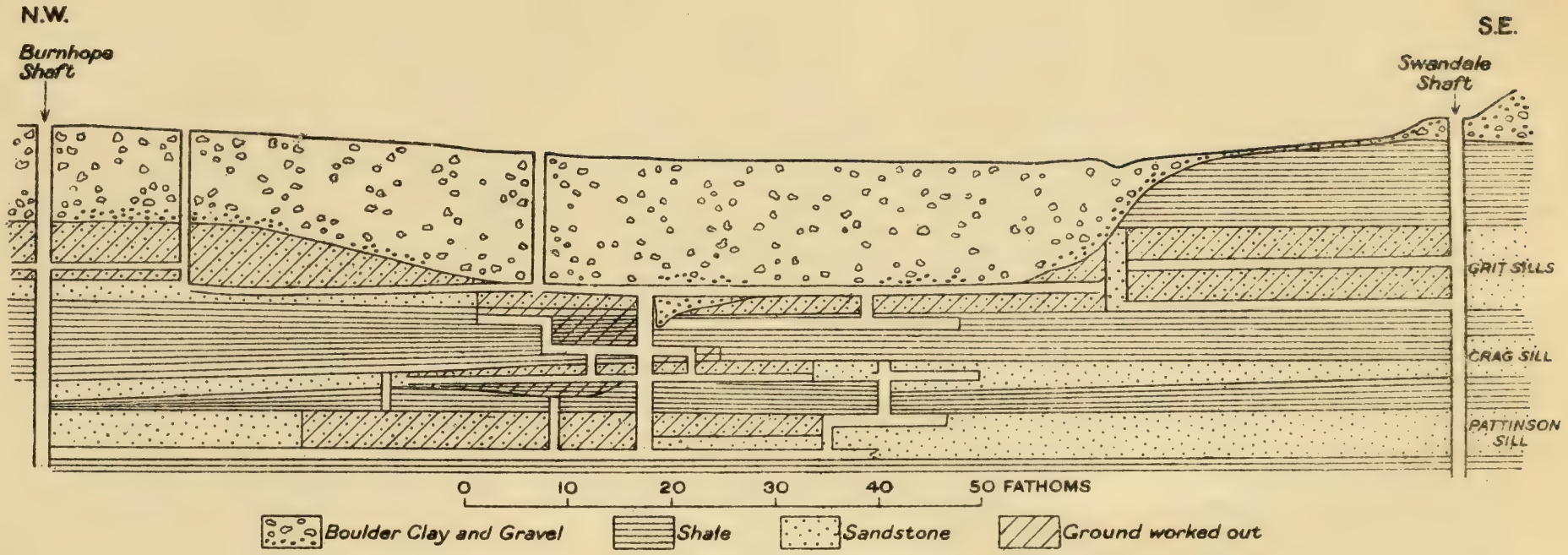
A shaft was sunk in 1875 to a depth of 35 fthms., about 60 yds. north of the Burnhope Burn, the southern boundary of the property.

The workings, if the information on the mine-section is complete, were confined to the Grit Sill, and were extended southwards to the boundary, but the section (really that of the Burnhope Mine), does not show the workings to the north of this shaft (*see* Plate 7). There is also an adit-level which is reported to have broken into ancient workings.

Some notes on this mine possessed by the family of a former manager state that the vein when first struck yielded lead-ore to the value of £70 per fathom, but that further extension laterally and vertically was not profitable.

Burnhope Mine.

The shaft is situated about 200 yds. south of the stream, and has been sunk to a depth of 33 fthms. The surface of the ground is a few feet lower here than where the Swandale Shaft stands, so that each shaft ended in the same "plate,"



SECTION OF BURNHOPE AND SWANDALE MINES.

practically at the same level. The workings, although also on a small scale, are deeper and more extensive than those of Swandale Mine, and the vein has been wrought in all three sills. The section here produced (Plate 7) shows the extent of the workings and their relationship to those of the Swandale Mine. It also reveals the presence of a pre-glacial valley between the two shafts.

The mine began operations a few years later than Swandale, but survived its neighbour by only a few months, for when, according to local account, Swandale closed down, it found itself unable to cope with the water.

Harehope Gill Mine.

Harehope Gill, the oldest of the three, was opened out about 1850, or soon after, and was abandoned before 1870.

The shaft is said to have reached a depth of 58 fthms., and the workings, it would seem, were mainly or wholly in the Pattinson's Sill, and in a higher sandstone.

Summary of Returns.

Swandale Mine.

Lead-ore, 1876–1887 (1878 and 1881 missing), 10 years	266 tons.
Lead and silver, less complete:	
Metallic lead in lead-ore	78 per cent.
Silver per ton of lead	4·2 to 24·0 oz.

Burnhope Mine.

Lead-ore, 1880–1887 (1881 missing), 7 years	1,052½ tons.
Lead and silver, less complete (Silver returned for 1887 only):	
Metallic lead in lead-ore	74 per cent.
Silver per ton of lead	15 oz.

Harehope Gill Mine.

Lead-ore, 1852–1866 (1855–7 and 1865 missing), 11 years	219 tons.
Silver less complete, 5 years:	
Metallic lead in lead-ore	69 per cent.
Silver per ton of lead	8 oz.

There are indications of other veins carrying barytes, and in some cases lead, on the north side of Burnhope Burn, west of the Swandale Vein. Several shafts have been sunk, and a level over 300 fthms. in length has been driven from the bank of the stream close to Pedamsoak Wood.

Charles I. upon his accession made a grant of all silver mines within 10 miles of Muggleswick, to the Duke of Buckingham. The London Lead Company acquired the lead mines within the Manor of Muggleswick in 1725, and occupied Feldon Smelting Mill, erected in the reign of Charles II.[1] The

[1] Robert Surtees, "The History and Antiquities of the County Palatine of Durham," 1820, Vol. II., p. 361.

ruins of this mill are still standing in the angle formed by the Feldon and Burnhope Burns, 1 mile above Edmondbyers.

THE DERWENT MINES.

The mines around the head of the Derwent have long been known as the Derwent Mines, for though extending over more than one estate, they were for long worked as a single enterprise. The principal mines are situated close to Blanchland and Hunstanworth, but there are several smaller mines and trials higher up the valley.

The lease of the mines, or at any rate of those comprised in the sequestrated estate of Thomas Forster, was acquired by the London Lead Company[1] from the purchaser, a Mr. Stoddart, about 1725. This company retained the mines until 1807, when Mr. Skottowe, the owner at that time, not only refused to renew the lease, but prosecuted them for neglecting the mines and for allowing their employees to misuse the property. He obtained damages for a considerable amount.

The lease was then taken up by a local syndicate, Messrs. Easterby, Hall & Co., at a royalty of one-seventh. This company installed new machinery, including powerful steam engines, and developed operations down into the Great Limestone, which had hitherto been unexplored. The cost of these developments overtaxed the financial resources of the syndicate, and in 1810 the mines fell into the hands of their principal creditors who successfully worked them under the name of the Derwent Mining Company.[2] This company retained the lease until 1883, when the Hunstanworth Mines, the last to be worked, were abandoned. Since that date all the mines have remained in disuse.

Mines in Northumberland near Blanchland. Shildon, Reeding and Beldon Mines.

Maps.—One-in. (Geological) Old Series, Sheet 106 S.E. New Series, Sheet 19. Six-in. (Geological) Northumberland, Sheet 108 N.E. Durham, Sheet 16 N.E.

These old mines, lying to the north and to the west of Blanchland, are situated upon a belt of N.E.–S.W. veins which run between the Shildon and Beldon Burns. The belt is rather

[1] The "London Lead Company," more correctly styled "The Governor and Company, for smelting down Lead with Pit Coal and Sea Coal" received its Charter from William and Mary in 1692. It was founded for the purpose of smelting lead at Bristol, but subsequently extended its activities to other parts of England and Wales and became the lessee of the most important mines in the Derwent Valley, Alston Moor and Teesdale. Its activities in the north date from 1704 with the acquisition of the Ryton Works, erroneously described as "in Alston Moor." It only relinquished the lease of the Teesdale Mines in 1902, shortly before it formally wound up its affairs in 1905.

[2] Mackenzie, "View of the County of Northumberland," 1825, Vol. II., p. 359.

more than ½ mile in width in the Shildon ravine, but the veins converge towards Beldon Shields and there appear to be cut off by N.W.–S.E. faults. They have not been followed far east of Shildon Burn.

The undermentioned veins have been wrought at Shildon :—

Gin-in-the-Wood Vein (400 yds. N. of Blanchland), Sluice Vein, Garden House Vein, Old Shildon Vein, New Shildon Vein, Fellgrove Vein, and Stand-alone Vein.

The first three have been proved for a short distance only, west of Shildon Burn, but the others have been wrought at the Reeding and the Beldon Mines, and their track across the country is marked by old shafts. An east-and-west vein, named Andrew's Vein, crosses the Fellgrove and Stand-alone Veins on the N.E. side of Shildon Burn. According to an old report the veins were of no great thickness, and Hodgson[1] the historian states that they incline to the north.

The strata that outcrop around Blanchland and Hunstanworth include no bed lying much below the Fell Top Limestone, but the deeper shafts at Shildon and Beldon penetrate to the Great Limestone.

All the veins carry fluorite, but at Shildon they also contain a large amount of chalcedony, which is the most abundant mineral on the refuse heaps. The chalcedony is an opaque white variety, variegated by translucent bands of a pale-blue colour, and occurring in botryoidal form. The nodules frequently enclose cubes of fluorite, and are usually coated with minute crystals of quartz. A small amount of blende was picked up around the Beldon Shafts.

Shildon Mine.

This mine is situated on Shildon Burn, north of Blanchland, which commands the entrance to the ravine. It is one of the oldest in Northumberland, dating at least from the 15th century (*see* p. 8). It continued operative until the middle of last century, but was closed many years before the more extensive mines on the Durham side of the Derwent. Wallis[2] in 1769 relates that "the lead mine at Shilden was very rich till of late years. It now gives employment to several hands, and has two subterrene engines to carry off the water."

Some useful information relating to the mine at the beginning of the 19th century is supplied by Hodgson.[3] At that time four veins were being worked, namely, the "Old Shildon," the "New Shildon," the "Fellgrove," and the

[1] "A History of Northumberland," Vol. VI., p. 340. Quoting from Hodgson's Note Book. [The Rev. John Hodgson's collection; Bywell Guard Book, p. 32.]

[2] "The Natural History and Antiquities of Northumberland," Vol. I., p. 121.

[3] *Op. cit.*

"Stand-alone." "The Old Shilden,"[1] he says, "has been much worked on the west side of Shilden Burn in ancient times as appears from the old pits and rubbish heaps."

He tells us, moreover, that the sills which have been most productive of lead-ore were the Slate Sill, Hipple Sill, "High Ground Sill" (High Grit Sill) and "Low Ground Sill" (Low Grit Sill), and that the last two were the most productive and contained the ore "intermixed with chalcedony which is not found in any other strata."

The mine was entered by an adit-level at the lower end of the ravine, and the veins were reached by a long cross cut driven in a northerly direction. Along the line of this cross-cut shafts have been sunk upon the Gin-in-the-Wood, the Old Shildon, the New Shildon and the Fellgrove Veins. The Engine Shaft (the one on Old Shildon Vein) was 105 fthms. in depth; the other shafts were known by the name of the vein upon which they stood.

These details have been gleaned in part from an old plan of the mine and in part from a report by Mr. J. Pears Walton, but the plan appears far from complete, and the only definite information that could be deduced from it respecting the extent of the workings was that the Old Shildon Vein had been worked at least 250 fthms. west of the Engine Shaft, and that the Fellgrove had been worked 60 fthms. east and 210 fthms. west of the Fellgrove Shaft.

A steam-engine performed the necessary pumping, and according to Mr. Walton the top of the water stood 17 fthms. below the surface at the Engine Shaft, *i.e.*, 7 fthms. below the adit-level.

The mine has supplied no independent returns; in fact it is stated in a recent report upon the Derwent Royalties by Mr. J. W. Hetherington, that the late Derwent Mining Company carted the ore to their main dressing-floors 2 miles distant.

Reeding Mine.

On Reeding Burn, near the farmstead known as Birkside, rather more than a mile due west of Blanchland, and a little less than a mile S.W. of Shildon Mine.

No information could be obtained respecting the underground workings, but shafts, adit-mouths and overgrown refuse heaps mark the site of operations.

A plan of the Derwent Mining Field, dated 1852, shows three levels, one driven directly into and along the Old Shildon Vein, another similarly constructed in respect to the New

[1] Shilden is the older and more correct spelling. Earlier documents refer to the Mine of Shyldeyn.

Shildon Vein, and the third (a side level) giving admittance into both the Fellgrove and the Stand-alone Veins.

Beldon Mine.

At Beldon Shields on Beldon Burn, 2½ miles W. by S. of Blanchland and 2 miles S.W. of Shildon.

The veins wrought at Beldon are in all probability those worked at Reeding Mine, namely, the Old Shildon, New Shildon, the Fellgrove and the Stand-alone Veins, with one or more cross veins. The mine has been long idle and little information concerning the veins can be added to that already placed on the Geological Survey Maps. According to these the Fellgrove and Stand-alone Veins intersect at a small angle some 700 yds. N.E. of the mine, and between them a number of strings have been encountered. Both are cut off immediately west of the shafts by a cross-fault which throws down to the N.E. and is well exposed in the south bank of the stream. To the east of the shaft and on the south side of the burn another cross-vein (an assumed continuation of the Linnbank Vein) cuts off Old Shildon Vein, and west of them, running east and west parallel with the burn, is a third cross-vein, known as the Beldonshield Vein.

A section still extant[1] affords some additional detail respecting the character of the two principal veins and the strings to which they give rise, and records the depth of the two shafts and the strata through which they pass. According to this section the throw of the Fellgrove Vein decreases appreciably in amount from the surface downwards.

An adit into these veins has its opening east of the shafts, while still further east there is a level into the Old Shildon Vein.

A steam-engine erected by the Derwent Mining Company during the earlier part of the 19th century supplied the power.

Returns are recorded for two years only, 1863–4, 73 and 70 tons of ore respectively. These 143 tons of ore are computed to have yielded 67·4 per cent. of metallic lead and 18 ounces of silver to the ton.

Acton Mill.

Lead was smelted near the Acton Burn, N.E. of Blanchland, during the 18th century. The Mill, erected prior to 1737, was occupied by the London Lead Company. It fell into disuse about 1800 and was dismantled by their successors early in the 19th century.

[1] This tracing is preserved at the offices of the W.B. Lead Company, Allenheads. It was possibly executed by Thomas Sopwith whilst Mineral Agent to Mr. W. B. Beaumont, or by his former pupil, T. J. Bewick.

Mines in Durham near Hunstanworth.[1]

Jeffrey's Rake and Ramshaw, and Whiteheaps Mines.

Maps.—One-in. (Geological) Old Series, Sheet 102 N.E. New Series, Sheet 25. Six-in. (Geological) Durham, Sheet 16 N.E., S.E.

The mines are situated on Bolts Burn, 1 mile and 1½ miles respectively south of Hunstanworth. They lie some 8 miles by rough moorland road from Stanhope Railway Station and about 12 miles by good road (except for the first mile or so) from Riding Mill Station.

Operations in these mines were chiefly confined to the strata above the Great Limestone, principally to the High Grit Sill, Low Grit Sill, Crag Sill, Pattinson's Sill, Little Limestone, High Coal Sill and Low Coal Sill, that is, with exception of the Little Limestone, in thick arenaceous beds. Most of the veins have been tried, and some of them worked to a small extent in the Great Limestone, but hereabouts this bed has up to the present proved almost unproductive.

At the Ramshaw Shaft, in the bottom of the valley, the limestone lies 72 fthms. below the surface, and in the other shafts at a much greater depth—140 fthms. in the case of Taylor's Shaft. The strata throughout most of the workings lie almost horizontally and are but slightly displaced by the veins.

The veins are filled with fluorite, and much galena has been raised from them, but blende only occurs in very small amount.

Jeffrey's Rake and Ramshaw Mines.

The Jeffrey's and Ramshaw Veins appear to be three almost parallel N.E.–S.W. lodes, which intersect at a small angle near Bolts Burn. East of the intersection they are known by the former name, and to the west of it by the latter. If this interpretation is correct, Jeffrey's North Vein becomes Ramshaw South Vein, but the exact relationship of the six diverging branches is doubtful. Between the veins are numerous strings. They are crossed by the Burntshieldhaugh Vein (N.N.E.–S.S.W.), the Whiteheaps White Vein (N.W.–S.E.), and to the north the Shilford-Haugh Vein, trending W. by N.–E. by S.

The Jeffrey's–Ramshaw Veins have been wrought for about a mile east of Bolts Burn, and for about half that distance west of the stream.

Access to the working was by adit-levels and by shafts. The longest and most important of the levels was the Deborah Level, driven south-eastwards from the side of Bolts Burn to Jeffrey's South Vein, a distance of about 300 fthms.; there was also an adit near Jamieson's Mill and another at Ramshaw

[1] "The Derwent Mines" where the term is used in a more restricted sense than that employed here.

Shaft. Of the numerous shafts the following give a general idea as to the depth to which the ground has been explored, and show the increase in depth of the workings both eastwards and westwards from Bolts Burn.

Shaft.	Depth in Fathoms.	Stratum reached.	Vein sunk in.
Taylor's - -	140	Top of Great Limestone	Jeffrey's Middle Vein.
Presser Engine	134	Into Quarry Hazle - -	Jeffrey's South Vein.
Jeffrey's - -	127½	Bottom of Great Limestone.	,, ,, ,,
Westgarth -	110	Into Great Limestone -	,, ,, ,,
Jemmy's -	83	,, ,, ,, (Bolts Burn).	Between the veins.
Ramshaw -	86	Bottom of Great Limestone.	Intersection of veins.
Pears - -	135	Into Quarry Hazle - -	Ramshaw South Vein.

The workings in the three veins are connected by numerous cross-cuts, so that at a particular random one vein may be entered and worked from a level in another. The number and position of the levels vary a little at the different shafts; in Jeffrey's Mine most of them lie at or about 20, 30, 40, 45, 50, 70, 80 and 95 fthms. below the adit, but in Ramshaw Mine the lowest one would seem from the plans available to be the 80-fthm. level.

The following details concerning the extent to which Jeffrey's Veins have been worked are given by J. Pears Walton in a report drawn up in 1890.

The North Vein.—The vein has been extensively and productively worked for about 135 fthms. east of Jeffrey's Shaft; beyond this point it has been followed in unproductive ground for about 105 fthms. It was also unproductive where still further east it was cut by a cross-cut from Taylor's Shaft.

The Middle Vein.—The Middle Vein and its branches have been extensively worked, and have proved productive further east than either the North or South Veins. They were productive for over 100 fthms. east of Taylor's Shaft, but then became poor; they have been followed, however, 80 fthms. in unproductive ground. Beyond this point there still remains some 600 fthms. of unproved ground.

The South Vein.—This has produced ore for 40 fthms. east of Taylor's Shaft, and has been pursued in unproductive ground for another 55 fthms.

Concerning the Ramshaw Veins, less definite information has been obtained. None of the veins would seem, from an

account given by T. J. Bewick, to have been very productive, the Middle Vein having produced the most ore. It has been worked beyond its intersection with the Whiteheaps White Vein, but neither the South Vein nor the North Vein have been worked as far as that point. The South Vein is described as dwindling to a mere string before reaching the White Vein and the North Vein as having been worked only from a shallow adit.

The Burntshieldhaugh Vein (or, to be more correct, a vein reasonably assumed to be a continuation of that lode) has been opened out in the Jeffrey's Rake Mine, and the Whiteheaps White Vein has been wrought at Ramshaw. The Shilford–Haugh Vein, which outcrops in the bottom of the valley, has not proved remunerative.

From all accounts Jeffrey's Rake Mine has been the most extensively worked of all the Derwent Mines, and its period of activity extended over nearly 200 years at least. It was leased by William Forster of Bamborough to a Thomas Rawlins of Durham in 1690,[1] and was worked up to 1883.[2]

The steam-plant installed by Easterby, Hall & Co. between 1807 and 1810 was, under the Derwent Mining Company, discarded, and water power reinstated soon after the company came into possession. Mackenzie gives the following account of the installation and of the plant which continued in use up to the closing of the mines.[3] "Water engines have again superseded the use of steam engines in the [Derwent] Lead Mines, as, from the great improvements made in water-wheels and water pressure engines, they have been found to be nearly as effective, and far less expensive than steam engines. Formerly [under the London Lead Company] the supply of water was divided among a number of wheels, and thus rendered of little power; but it is now collected, and, by an admirable arrangement, the whole body of water available is made to pass over and supply, first a pressure engine at Whiteheaps, next a water-wheel 44 feet in diameter at Ramshaw, and afterwards a water-wheel 48 ft. in diameter at Jefferies; all pumping, besides going over and supplying several wheels for the crushing mills and smelting mills."

The main reservoirs were Sikehead Dams, east of Whiteheaps, and the system was worked by means of horizontal pumping-rods or spears nearly a mile in length, connecting the three mines.

Lead was smelted as well as raised here, both under the London Lead Company and the Derwent Mining Company, and

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[1] "A History of Northumberland," 1902, Vol. VI., p. 341.

[2] The last few returns made by the Derwent Mines are headed "Jeffrey's Derwent."

[3] "View of the County of Northumberland," 1825, Vol. II., p. 490.

smelting was only discontinued at or shortly before the abandonment of the mines. Jeffrey's Mill was erected early in the 18th Century (before 1737).

The greater part of these two mines has been leased within late years to the Consett Water Company, who pump the water from the extensive workings.

Whiteheaps Mine.[1]

The Whiteheaps Veins comprise several lodes intersecting near Bolts Burn, about 500 yds. south of the Jeffrey's and Ramshaw Veins, namely, the White and Red Veins, two almost parallel lodes running E.S.E.–W.N.W., the Farneygill Vein (N.E.–S.W.) and the Company's Vein (E. and W.). Associated with these are the usual branches and strings, and south of the complex is the Boltshead Vein (E.N.E.–W.S.W.). The most important of these is the White Vein, which has been worked for about 500 fthms. both to the east and to the west of Bolts Burn—from about 190 fthms. east of Ellen's and Ruth Shafts to a little beyond MacDonnell's Shaft. The vein attains a width of 50 to 60 ft., but is narrow in places. It is filled with fluorite and country-rock, and as seen at the surface near MacDonnell's Shaft is a clean compact deposit of the mineral about 50 ft. in thickness. The displacement it effects is to the south. A considerable amount of galena has been raised from it, and from the Red Vein, particularly in the vicinity of the Ellen and Ruth Shafts, and of Whiteheaps Shafts, where the veins are described as being exceptionally rich. At MacDonnell's Shaft the White Vein was not particularly productive.

The Red Vein and the Red Vein String are reported to dwindle to mere joints west of Whiteheaps, though the latter is said to be a fine sparry vein which has yielded much ore at the 30-fthms. level at that shaft. The Company's Vein is described as "contracted and poor," and the Farneygill Vein is reported as 2 ft. to 4 ft. wide and composed of "spar and rider."

There is an adit-level into the mine, driven southwards from the side of Bolts Burn, a little to the north of Crag Shaft. The principal levels running along the veins taken from a plan at Ellen's and Ruth Shafts are the 30-, 40-, 50-, 62-, 70-, and 79-fthm. levels. Below are given details of the more important shafts.

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[1] The remarks concerning this mine are made with some reservation since the plans and reports available are not altogether consistent. The clearest information, and that in closest agreement with the mine-plans, is that given by J. P. Walton, and from this source the following notes have been chiefly compiled, but some details from T. J. Bewick's report are included.

Whiteheaps Mine.

——	Depth.	Stratum reached.
Ellen's and Ruth Shafts (East end of workings).	About 100 fthms.	To Pattinson's Sill.
Crag Shaft - - - -	40 fthms. - -	—
Whiteheaps Shaft - -	98 fthms. - -	Through Great Limestone and Tuft.
Whitsun Shaft - - -	30 fthms. - -	To adit.
MacDonnell's Shaft (West end of working).	50 fthms. - -	To High Grit Sill.

Boltshead Vein has only been superficially worked. South of Burnhead Dam an east-and-west vein has been recently proved.

Smaller Mines and Trials in the Neighbourhood of Knuckton Burn, West of Hunstanworth.

Knuckton Burn.

The Linnbank Vein.—The vein crossed Knuckton Burn about ½ mile above its confluence with Beldon Burn at Derwent Head. It has been once wrought on the north side of the stream, probably to no great depth and presumably for a length of 200 fthms. (J. W. Hetherington's report). Old shafts and spoil-heaps mark its position, the latter mainly composed of ferruginous material carring some blende. The vein has been tried on the south side of the stream by a level, and sought still further south by shafts, but concerning these trials no information has been obtained.

Little Knuckton Burn (Yad Sike Level).

An adit-level has been carried eastwards from where the Yad (or Yaud) Sike enters Little Knuckton Burn for 255 fthms. and a shaft has been sunk on it. A vein was cut 165 fthms. from the mouth, but does not appear to have been worked. (J. P. Walton's report).

Smithy Cleugh.

Trial for lead was made early in the 19th Century at the foot of Smithy Cleugh, 1½ miles above Derwent Head, where it was assumed the White Vein would cross Knuckton Burn. A level was driven westwards and is reported to have cut three veins (J. P. Walton's report). A shaft was sunk upon the middle of these (White Vein?). These veins have also been tried both by level and by a shaft on the north side of the stream. T. J. Bewick stated that the spoils contained "rider and spar, but the specimens were not encouraging."

Grindstone Cleugh.

Two short levels were driven prior to 1850 in Grindstone Cleugh, 2 miles above Derwent Head. According to the report by T. J. Bewick, the lower level was carried for some 70 fthms. in a south-western direction along a weak and unproductive vein in what was believed to be the Low Grit Sill. The vein, it is stated, was usually only 1 or 2 in. and rarely exceeded 6 in. in width. It carried rider, some fluorite, quartz and occasionally "stones" of ore, and near its forehead appeared to split into two branches, neither of which bore indications of productiveness.

The higher level (called the Grindstone Cleugh Level) was about 300 fthms. in length. It is stated to have cut the "Grindstone Cleugh Vein" 116 fthms. from the mouth and beyond this several weaker veins not regarded as worthy of further trial. A shaft was sunk to the "Grindstone Cleugh Vein" and a rise was carried from the level into the Hipple Sill; some ore was obtained but the trial was discontinued in 1862. Bewick points out that in this part of the field the arenaceous beds which carried the lead at Jeffrey's Rake, Ramshaw and Whiteheaps are much thinner than at those mines.

Some cubes of galena were picked up by the side of the stream, where some superficial investigation had lately been in progress, and higher up other strings have been observed.

Near the foot of Grindstone Cleugh and on the west side of the stream upon an exposed elevation, angled between the Cleugh and Knuckton Burn, there lies a quantity of lead-slag of some remote period. It is mostly vitreous and of a green or light-green colour grading into black, but some specimens are scoriaceous and include pieces of charcoal. They all contain globules of metallic lead and under the microscope some specimens exhibit interesting stages of devitrification. Analyses of three samples were made by Mr. T. E. Hull, F.C.S., of Huddersfield.

	Per cent.
Sample I.:	
Silica	25·64
Iron and alumina	52·88
Lime	Trace
Magnesia	2·46
Lead sulphide	4·21
Free lead	15·21
Sample II. (Lead only determined):	
Lead	17·67
Sample III. (Lead only determined):	
Lead	68·06

Knuckton Head.

Still higher up the Knuckton Burn, ¾ miles above Grindstone Cleugh, where the stream is joined by the Great and Little Espey

Sikes, two short levels are recorded on the general plan of the Derwent Mining Field made in 1852, but no veins are indicated. Both levels are on the north side of the burn. Some veins or strings are, however, marked on another old plan of the field, near or beyond the heads of the sikes.

Mines and Trials within the Drainage of the Devil's Water.

Devil's Water.

No mining of importance has been carried on within the valleys of the Devil's Water or of its tributary streams, although a trial has been made of a vein near the head of the Devil's Water, S.W. of Steel Crags; the Burntshieldhaugh Vein was worked at Burntshieldhaugh Mine and there was a small mine popularly known as Cobbler's Venture on Rowley Burn.

Burntshieldhaugh Mine.

Maps.—One-in. (Geological) Old Series, Sheet 106 S.E. New Series, Sheet 19. Six-in. Northumberland, 103 S.W.

The Burntshieldhaugh Vein runs N.N.W.–S.S.E. The mine is situated on the east side of the Devil's Water $\frac{1}{2}$ mile north of the farmstead which gives its name to the vein and mine. Ruins by the side of the stream show that ore was raised and dressed here, but evidently long ago.

Cobbler's Venture Mine.

Maps.—One-in. (Geological) Old Series, Sheet 106 S.E. New Series, Sheet 19 Six-in. Northumberland, 103 S.W.

This mine lies some 2 miles N.W. of Burntshieldhaugh Mine and is about 3 miles by road S.W. of the village of Steel. It was worked by a small local syndicate and was operative between 1868 and 1874. The workings have been described as shallow and small; there was apparently only one shaft. The vein wrought is probably the Burntshieldhaugh Vein which is bearing in this direction. This is the most northerly lode of the main mining field.

The stratigraphical horizon of this and of the Burntshieldhaugh workings (unless the latter extended to a considerable depth, which is unlikely) is that of the sills lying near the Fell Top Limestone.

Dukesfield Smelt Mill.

On the Devil's Water near the village of Steel stood the Dukesfield Smelt Mill. It was erected during the 18th century by the Blacketts of Allendale, and here a large proportion of the lead raised from their mines was smelted and refined. The mill was dismantled about 1834.

Summary of Returns.

The returns include the total produce of the Derwent Mines, but almost the whole of the ore was raised in the Hunstanworth group during the period covered by the returns.

Lead ore, 1845–1883, 39 years	39,409 tons.
Lead, 1845–1883. 39 years	28,885 tons.
Silver, 1853–1883 (1865 missing), 30 years	220,383 ozs.
Metallic lead in lead-ore	73 per cent.
Silver per ton of lead	10 ozs.

THE ALLENDALES.

The Allendale mining district embraces the higher parts of the East and West Allen Valleys and is contiguous to those of Weardale and Alston Moor.

In East Allendale veins carrying ore have been proved as far north as Holmes Linn, 4½ miles north of Allenheads, and in West Allendale as far as Ninebanks, which lies approximately on the same latitude. Lead-mining is now carried on only at Sipton in East Allendale, and along the southern boundary of West Allendale.

The following section of the strata was compiled by T. Sopwith[1]. It differs only in its minor details from the section proved on Alston Moor (p. 69).

General Section at Allendales.

	Fms.	Ft.	Ins.
Plate	–	–	–
FELL TOP LIMESTONE	0	4	3
FELL TOP HAZLE	2	1	6
Plate	5	0	0
WHETSTONE SILL	1	2	0
Plate	2	1	6
Hazle	1	5	0
Plate	1	1	6
HIGH SLATE SILL	4	0	0
Plate	1	1	0
LOW SLATE SILL	3	5	0
Plate	4	4	0
White Hazle	1	3	6
Plate	3	5	6
"IRONSTONE" (Sandstone?)	0	3	6
Coal	0	1	6
FIRESTONE	4	5	0
Plate	3	4	0
WHITE TUFT or WHITE SILL	2	2	3
Plate	2	1	0
Girdle beds	0	3	6
Plate	2	0	3
PATTINSON'S SILL	2	0	0
Plate	3	1	6

[1] "An Account of the Strata of Northumberland and Durham as proved by Borings and Sinkings," 1910 Supplementary Vol., p. 3.

	Fms.	Ft.	Ins.
LITTLE LIMESTONE	1	3	9
Plate	3	1	9
Coal	0	2	0
HIGH COAL SILL	1	2	0
Plate	1	3	0
Coal	0	2	0
LOW COAL SILL	1	4	0
Plate	3	1	8
GREAT LIMESTONE	9	5	3
Tuft	1	2	6
Plate	3	2	6
Limestone Post	0	3	6
QUARRY HAZLE	4	4	6
Plate	5	2	6
Till Bed	2	0	9
FOUR FATHOM LIMESTONE	3	0	9
NATTRASS GILL HAZLE	3	1	0
Plate	5	3	6
THREE YARDS LIMESTONE	1	3	3
Plate	1	2	9
SIX FATHOM HAZLE	5	2	0
Plate	0	4	0
FIVE YARDS LIMESTONE	2	3	6

East Allendale and the greater part of West Allendale form a single estate, within which the whole of the lead-mining has been in the hands of the Lord of the Manor from the end of the 17th century to within recent years. These mines rank first in importance among those of Northumberland, and, together with Weardale and Alston Moor, form part of what was formerly the most productive field in the British Isles. Throughout the most flourishing period in the history of British lead mining, in the middle of the 19th Century, "The Allendale and Weardale Mines,"[1] the former owned, and the latter leased, by W. B. Beaumont, Esq., M.P., produced about one-ninth of the total lead ore raised in Britain.

A feature of particular interest in this field is the driving of long exploration levels both in the East and the West Valleys, the most important being the Blackett Level in East Allendale. There have been three smelting mills in the Allendales:—

Whitfield Mill.—Erected in the 18th century by the London Lead Company and situated near the confluence of the two streams, was dismantled prior to 1821.[2]

Allen Mill.—On the west bank of East Allen, ½ mile north of Allendale Town, was established during the 17th century[3]

[1] The term "Weardale Mines" does not imply the whole of the lead mines in that valley, but only those now owned by the Ecclesiastical Commissioners and formerly by the Bishop of Durham, and leased to Sir William Blackett and his successors.

[2] Westgarth Forster, "Treatise on the Section of the Strata, &c," 1821, p. 419, records "Whitfield Furnaces. Now in ruins. In the County of Northumberland; the property of William Ord, Esq."

[3] There is a reference to "Mr. Bacon at the Lead Works" in the Allendale Parish Register, 1692. George Dickenson, "Allendale and Whitfield," 1903, p. 54.

and passed into the possession of the Blackett family during the 18th Century. It closed down in 1896.

Allenheads Mill.—Erected in the 18th Century and closed in 1870 was a much smaller mill[1] and was owned and occupied throughout by the Blacketts and their successors.

Much of the ore raised from the Allendale Mines appears, however, to have been smelted at the Dukesfield Mill, which was situated on the Devil's Water at Steel, 4 miles south of Dilston.[2] (*See* p. 52.)

History of the Allendale Mines.

The little that is known concerning the early history of lead-mining in the Allendales has already been referred to in the general historical account (pp. 7–8), since "the mines in Hexhamshire" there mentioned can with much probability be allocated to these valleys. The Manor of Hexhamshire, for long an appurtenance of the Archbishopric of York, was appropriated by the Crown in the person of Henry VIII., and the estate became, through purchase in 1632, the property of the Fenwicks of Wallington, by whom it was sold to Sir William Blackett in 1694. From the Blacketts it passed to the Beaumonts, the present owners of Allendale.

In 1565 Matthew Bee of Ninebanks opened out three mines on his estate at Grewslacke, Spartywell, and Bates Hill, all south of the village. This led to his being prosecuted by the Crown in 1570.[3]

Although in the trial Bee pleaded that the mines did not repay the cost of working, it was shown that 200 loads of lead had been obtained during the five years that they had been active.

From this time onwards, mining, subject to fluctuation, has been in progress up to the present day. On acquiring the estate in 1694, Sir William Blackett at once began to work and develop the mines himself, and in 1696 purchased the lease of the mines owned by the Bishop of Durham, the royalty being apparently one-ninth.[4]

The Allendale and Weardale Mines remained under the sole control of the owners of Allendale until 1883. In that year Mr. W. B. Beaumont relinquished the lease of the Weardale

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[1] Westgarth Forster. *Op. cit.*, p. 416. Allen Mill; two roasting furnaces, five ore hearths, two refining furnaces, one reducing furnace. Allenheads Mill; one roasting furnace, three ore hearths, one slag hearth.

[2] J. Bailey and G. Culley, "General View of the Agriculture of the County of Northumberland," 1797, p. 22. "Allendale lead ore is smelted and refined at Dukesfield smelting mill and produces 7 or 8 ounces of silver from each fother of lead" [a fother = 21 cwts."]

[3] Special Commission No. 1720. The Queen *v.* Matthew Bee. *See* "A History of Northumberland," 1896, Vol. III., p. 10.

[4] Henry Louis, "Lead Mines in Weardale, County of Durham." *The Mining Magazine*, Vol. XVI, 1917, p. 20.

Mines, and in the following year associated with himself a number of other gentlemen as a limited liability company (the W.B. Lead Company) with a capital of £75,000 in £100 shares. The Company, however, could scarcely be said to have been more than a name.

At the time the lease of the Weardale Mines was surrendered, and onwards up to the closing of the mines in 1896 operations in the Allenheads Mines were confined to the veins in the county of Durham, which were retained by special arrangement. In West Allendale activity for many years was restricted to the great veins in the south. A few men were employed in the Scraithehole Vein in 1899, when the West Allen Royalty was leased to the Vieille Montagne Zinc Company. The underground work carried on in East Allendale between 1896 and 1907 was confined to maintaining in repair the Blackett Level. In the latter year, however, preparations were made for the opening of the Sipton Mines, which began raising ore in 1912.

DETAILED DESCRIPTIONS.

EAST ALLENDALE.

The veins of the eastern valley, with the exception of the Swinhope Vein, which carries blende and much iron, are all fluorite veins. The trials and mines include the Blackett Level, Sipton Mines, the Allenheads Mines, and Swinhope Mine.

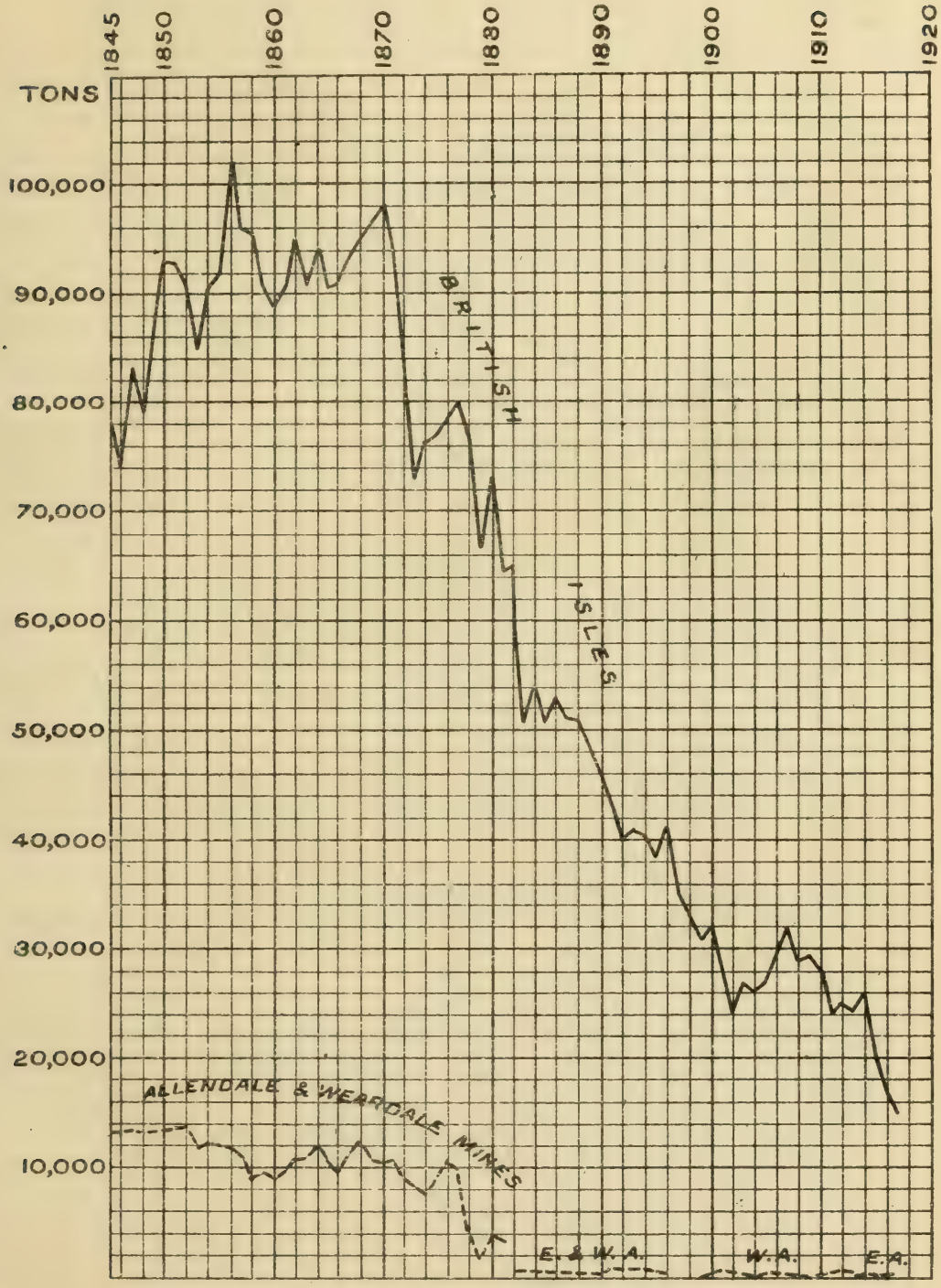
The Blackett Level.

This great level was projected by Thomas Sopwith for the two-fold purpose of exploration and the unwatering of the mines at Allenheads. It was planned to run from the Allen at Allendale Town to the foot of Gin Hill Shaft, Allenheads, a distance of nearly 7 miles, and has been driven for 4½ miles to a point a ¼ mile south of Sparty Lee, at an estimated cost of upwards of £250,000 (*see* Plate 9). Its gradient is approximately 1 in. to 50 ft., or 9 ft. per mile, and its dimensions for the most part are 7 ft. by 4 ft., but these measurements are not constantly maintained.[1]

Four shafts have been sunk upon it, namely at Studdon Dene, Holmes Linn, Sipton and Breckon Hill, 1 mile, 2¼ miles, 4 miles, and 5¼ miles respectively from the adit. The first shaft is 88 ft. in depth,[2] the second 192 ft., the third 330 ft., and the fourth, lying beyond the present forehead of the level, would have been 430 ft. if completed. The shafts were begun in 1855, and the adit started in 1859. The driving of the level was in progress until 1912, when the few men employed were diverted to the opening out of the veins at Sipton.

[1] George Dickenson, "Allendale and Whitfield," 1903, p. 53.

[2] This shaft does not reach the surface, but is in communication with it by means of a short drift.



E.A. EAST ALLENDALE MINES
W.A. WEST ALLENDALE MINES

Output of Galena
From the Allendale and Weardale (Beaumont) Mines
Contrasted with that of the British Isles.

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The mouth of the level is in the High Slate Sill, and the forehead has reached the shale below the Five Yards Limestone, so that some 650 ft. of strata, gently inclined to the north, have been traversed. At the foot of Studdon Dene Shaft the level is running in the Firestone; at Holmes Linn in the Great Limestone. Sipton Shaft reaches the Plate below the Six Fathom Hazle, and the Breckon Hill Shaft, if continued, would penetrate into the Scar Limestone. This would be the lowest bed encountered, for between the Breckon Hill Shaft and the Gin Hill Shaft, $2\frac{1}{2}$ miles to the south, the strata are nearly horizontal though actually anticlinal.

The level has been cut through a large number of faults of small throw, mostly trending N.E.–S.W., and for the most part hading and throwing to the south. They are reported to be barren north of the Holmes Linn Shaft, but thence southwards a number of them contain spathic and metalliferous deposits. The most promising are Whintings Vein, Esp Vein, Four Fathom Vein, and St. Peter's Vein.

Whintings Vein.—This has been followed in the Quarry Hazle and the Three Yards Limestone, and has been described as a wide "soft" vein. It carried some ore, but the walls and arch of the level collapsed through pressure. The vein trended W. of N. and E. of S.

The Esp Vein.—(*See* next page.)

The Four Fathom Vein.—This was proved 29 fthms. south of Sipton Shaft in the Six Fathom Hazle, and was followed by a higher level in the Four Fathom Limestone, driven from the side of the shaft. According to the plan it runs in the form of a crescent, convex to the north, branches at the east end, and is crossed by numerous strings. It is probably a complex of several veins. It was worked to some extent in 1865–66, but reported as not very productive.

St. Peter's Vein.—Was cut in the Three Yards Limestone 800 fthms. south of Sipton, and is now worked in the Great Limestone above the Blackett Level.

Mining now in progress at Sipton, began in 1912 with the opening out of the Esp Vein and the sinking of St. Peter's Shaft. For some years prior to this, 1907 and onwards, the operations consisted in gaining access to the St. Peter's Vein from the Blackett level by means of a flank level and rises. It was during these operations that an explosion of gas occurred, believed to have been derived from a thin seam of coal lying immediately below the Four Fathom Limestone and exposed at the top of a 100-ft. rise. Nevertheless, the explosion occurred in the flank level 80 fthms. away from the foot of the rise.

Search for veins in the neighbourhood of Sipton was made as far back as the beginning of the 19th Century, when a level was driven eastwards from Sipton Cleugh.

Sipton Mine.

Maps.—One-in. (Geological) Old Series, Sheet 106 S.E. New Series, Sheet 19. Six-in. (Geological) Northumberland, Sheet 107 S.E.

Site.—Sipton lies on the west side of a good road between Allenheads and Allendale Town, and is $5\frac{1}{2}$ miles south of Allendale Railway Station.

The Esp Vein was cut by the Blackett Level, 500 fthms. north of Sipton Shaft. It there runs in the Four Fathom Limestone, and is a compact lode, with an average width of 4 ft. and an inclination to the south of about 3° from the perpendicular. At the eastern forehead the throw (to the south) is 6 or 7 ft., but at the western end of the workings only a few inches. Contrary to expectation the vein continued productive in the shale above the limestone, and is still productive in the Quarry Hazle, *i.e.*, as far as it has yet been followed.

At the extreme eastern end of the workings in the Quarry Hazle, the vein retains the slight southern hade that it has in the limestone below. Westwards it is less steep, and bends towards the south. It is suggested that its new course will connect it with certain strings known to exist to the southward, and that after union with these it will resume a more upright position. Although the average width of the vein is about 4 ft., it varies even within the present workings from less than 6 in. to more than 6 ft.

The vein-material is almost wholly fluorite, and within this the galena runs as well-defined ribs. Quartz is present, more particularly against the cheeks, and also, although in very small amount, blende, siderite, and pyrites.

In the eastern forehead of the level in August 1918, the vein showed a width of 4 ft. of fluorite enclosing three ribs of galena and a few pieces of country-rock. The fluorite was strongly cleaved, parallel with the sides of the vein, suggesting that there had been movement after its deposition. Of the three ribs of ore those nearer the margin consisted of ordinary soft galena, irregular in form, and varying in width up to 1 ft., but the middle rib was formed of a hard compact fibrous variety, locally known as "steel ore," sheared throughout, and streaked by folia of fluorite. It proved to have the following composition :—

"Steel Ore."

(Analysis by Mr. T. E. Hull, Huddersfield.)

	Per cent.
PbS	87·00
FeS	9·46
Sb_2S_3	0·62
CaF_2	1·60
Insoluble matter	0·84

The thickness of the rib at this place was 9 in., and the sides were remarkably parallel, highly polished, and slickensided. The opposing cheeks of the fluorite carried a film of polished galena, and were impregnated for a certain distance with the mineral.

A few feet away from the forehead this rib, 6 in. wide, ran for some distance in the roof of the stoping, maintaining its thickness and its almost mathematically straight sides, although the vein had assumed more the character of a crush-breccia cemented by fluorite and galena. Still further away the "steel ore" became reduced to a ribbon a couple of inches in width. Near the western forehead of one of the headings the whole vein was not more than 6 ins. wide, and consisted merely of a few thin strings of fluorite; nevertheless, the slickensided surface of the fault-plane was in direct continuity with one of the cheeks of the rib of "steel ore." At this place the vein gave rise to a small flat of almost solid galena, and beyond this flat showed promise of opening out again. The slickensided surface has served as a useful guide to the miners.

A working level has been carried forward along the vein from the east side of the Blackett Level, and the forehead at the time these notes were made (1918) stood some 70 fthms. from the entrance; rises led upwards into "headings" which cross the Blackett Level, and the forehead of the lower of these had advanced about 60 fthms. to the west. The level is being rendered permanent by concrete walling and stone arching, and shoots are being erected every 15 fthms., each alternate shoot being accompanied by a ladder way.

The level rises 1 in. in 30 ft., but the rise in the strata is 1 in. in 10 ft.

The ore obtained is drawn to the foot of Sipton Shaft by a small petrol engine, and is raised by a hydraulic engine erected when the shaft was sunk some 60 years ago.

St. Peter's Mine.

Maps.—*See* Sipton Mine.

Site.—The shaft stands by the side of the Allenheads Road, two-thirds of a mile south of Sipton.

The St. Peter's Vein may be assumed to be a continuation of the Swinhope Vein, for it runs in the same direction, and approximately in line with that vein. Yet between the most easterly workings at Swinhope and St. Peter's Mine runs the Burtree Ford Fault.

As seen in the Great Limestone it is a wide vein like Swinhope, 15 to 18 ft. across, and consisting of an open mesh of vein-strings. It has a small hade, and a throw of $4\frac{1}{2}$ ft. to the north. Like the rest of the Allendale Veins it contains fluorite as its principal spar. The galena occurs as discontinuous ribs, as pockets, and as small vein-strings and isolated crystals,

enclosed in the fluorite. The vein showed a strong tendency to form "flats," those which were observed occurring at the horizon of the Low and High Flats of the Nent Veins.

One noteworthy flat was about $3\frac{1}{2}$ ft. high, and clearly defined above by an unbroken bed of limestone. The centre and greater part consisted of limestone traversed by numerous thin vein-strings of fluorite, which terminated against the shaly parting that formed its roof. This portion of the flat carried little ore, but on both sides occurred solid masses of galena. One of these masses filled almost the whole height of the flat, and was of considerable but, at the time, unproved extent. Blende occurs in insignificant amount only within the Great Limestone.

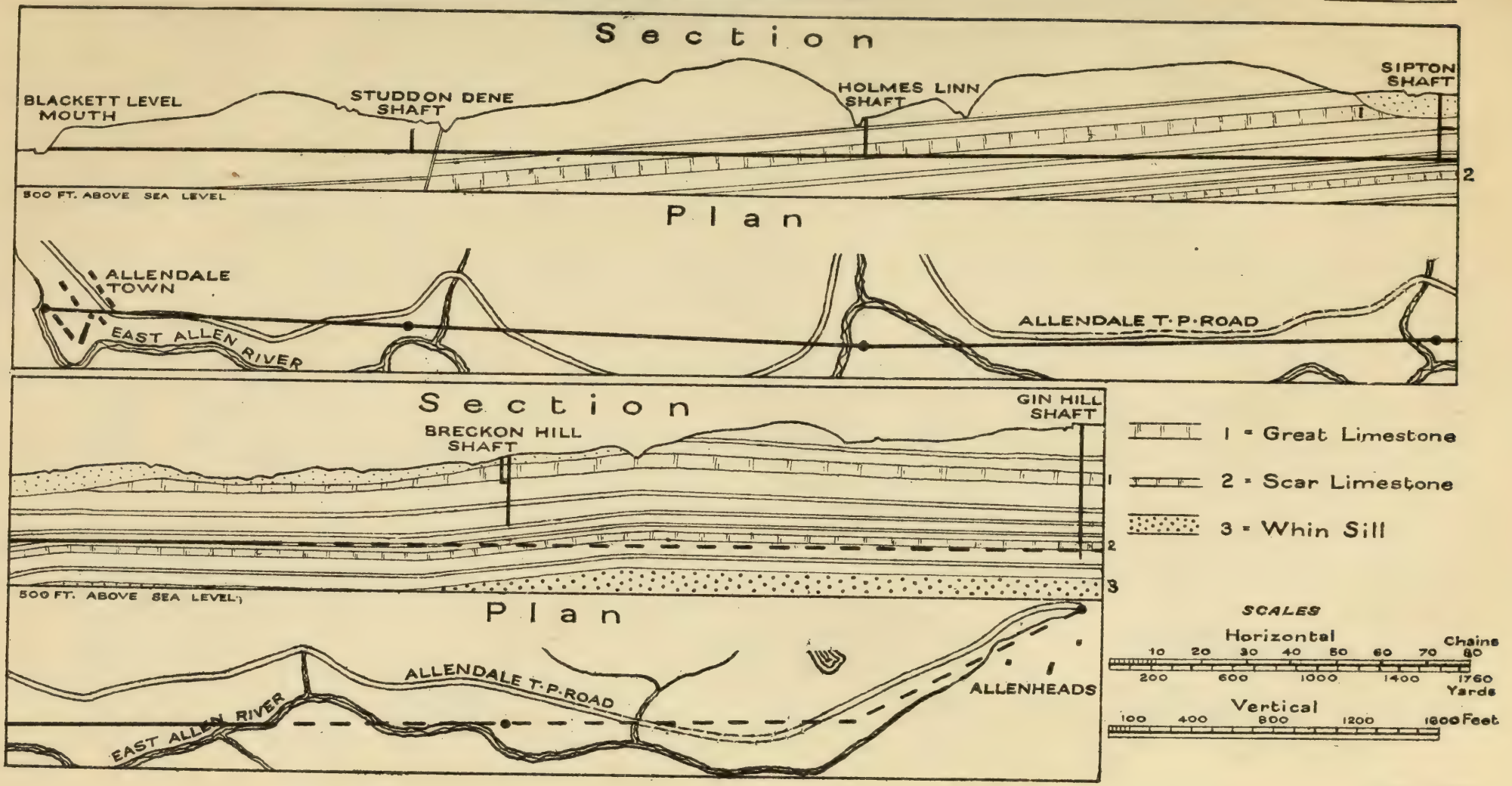
The shaft has been sunk a depth of 33 fthms. to the bottom of the Great Limestone. From the foot a level has been driven eastwards, the forehead of which, standing about 60 fthms. away from the shaft, is, by reason of the dip, near the top of the limestone. A small amount of work has been prosecuted about the level. The vein was not found profitable to work in the Five Yards or Four Fathom Limestone, although in the latter it yielded a little blende.

Both in the Esp and the St. Peter's Veins mining operations are only in their initial stages. As regards the Esp Vein, even within the compass of the present workings, half the Four Fathom Limestone is still intact and the vein is yet to be proved in the Great Limestone. The vein is not promising in a western direction, but eastwardly it is bearing well, and sound ground lies in front of it.

Dressing Plant.—The ore raised at Sipton and St. Peter's Mines is dressed at the former. After being picked over and the larger pieces dressed by hand, the material, which contains about 80 per cent. of lead, is ready for the smelter. Samples of particularly good quality are placed on one side as "potters ore," which in small quantity finds a ready market in India.

The ore is then fed through a hopper on to a raft-wheel, which permits the finer material to fall through its perforations ($\frac{1}{2}$-inch in diameter) and throws the remainder into a crusher which reduces it to the same degree of fineness. All the material is then carried by an elevator to the screening trommels which feed the various jigs. These, graded for five sizes, deal with particles 1·5 millimetres and upwards in size. The jig washing the finer grade of ore is fed by means of a hydraulic classifier. The still finer material passes on directly to the vanning table (also fed by a hydraulic classifier). The jigs produce four separations, namely, clean galena, "rich middlings" (mixed ore and waste), "poor middlings" (the same but poorer in ore), and waste.

The rich middlings are conveyed back to the trommels, but the poor middlings are crushed again. The middlings obtained from the vanning table are ground into a slime and led into



PLAN AND SECTION OF THE BLACKETT LEVEL

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C&R. LTD 746.

one or two buddling tanks. The partial separations obtained from the tanks are treated in a mechanically worked dolly-tub, the side of which is beaten by an automatic knocker.

The slime from the dolly-tub contains a small amount of ore which the plant is unable to remove. The quantity of blende present in the ore is too small to render separation profitable, and it passes away with the waste. The water from the dressing-shed passes through two filtering-tanks before it is allowed to enter the Allen. These tanks are connected at the bottom by pipes, and the floors of both are covered by 2 or 3 ft. of brushwood, through which the effluent passes in a fairly clear state into the river.

Allenheads Mines.

Maps.—One-in. (Geological) Old Series, Sheet 102 N.E. New Series, Sheet 25. Six-in. (Geological) Northumberland, Sheet 111 N.E., also Durham Sheet 15.

Site.—The principal entrance to the mines was at Allenheads, situate $4\frac{1}{4}$ miles by hilly road from Wearhead Railway Station and 8 miles by good road from Allendale Station.

Geology.—The veins form a small complex with convergence towards the east and west (Plate 12).

The Wentworth and Diana Veins form an east-and-west line, on the north side of which, and converging towards its western end, there are several veins, including the Christopher Mill Vein and the Allenheads Old Vein, with its branch, the Bretton Vein. The Allenheads Old Vein appears from the plans to leave the Diana Vein west of the Gin Hill Shaft, and then to bend back towards it again to form a "horse." It is to the east of the reunion that the east-and-west vein is known as the Wentworth Vein. The veins are cut off on the west by the powerful north-and-south Burtree Ford Dyke which throws down the strata 500 ft.

On the south side of the Wentworth and Diana Veins and converging towards the eastern end of the line (which coincides with the county boundary) are the Coronation, the Grindstone, Henry's and the Henrietta Veins. These are intersected by three cross-veins, namely, the West Cross Vein, the East Cross Vein and the Victoria Vein.

"Flats" in the Great Limestone are an important feature of the veins. They appear to be developed more particularly along the Wentworth and Diana line, Allenheads Old Vein, and at the eastern end of the workings where the veins from the south converge. No information respecting the width, hade or throw of the veins could be obtained. The matrix is fluorspar, carrying much galena but little blende.

Mining.—Plans and sections show that the veins lying within Northumberland have all been extensively wrought from the Grindstone Sill down to the Four Fathom Limestone,

chiefly at an early date and not for many years. The veins within the county of Durham, with the exception of Henry's Vein which has been well worked between the High Slate Sill and the Four Fathom Limestone, have not been much worked except in the Great Limestone.

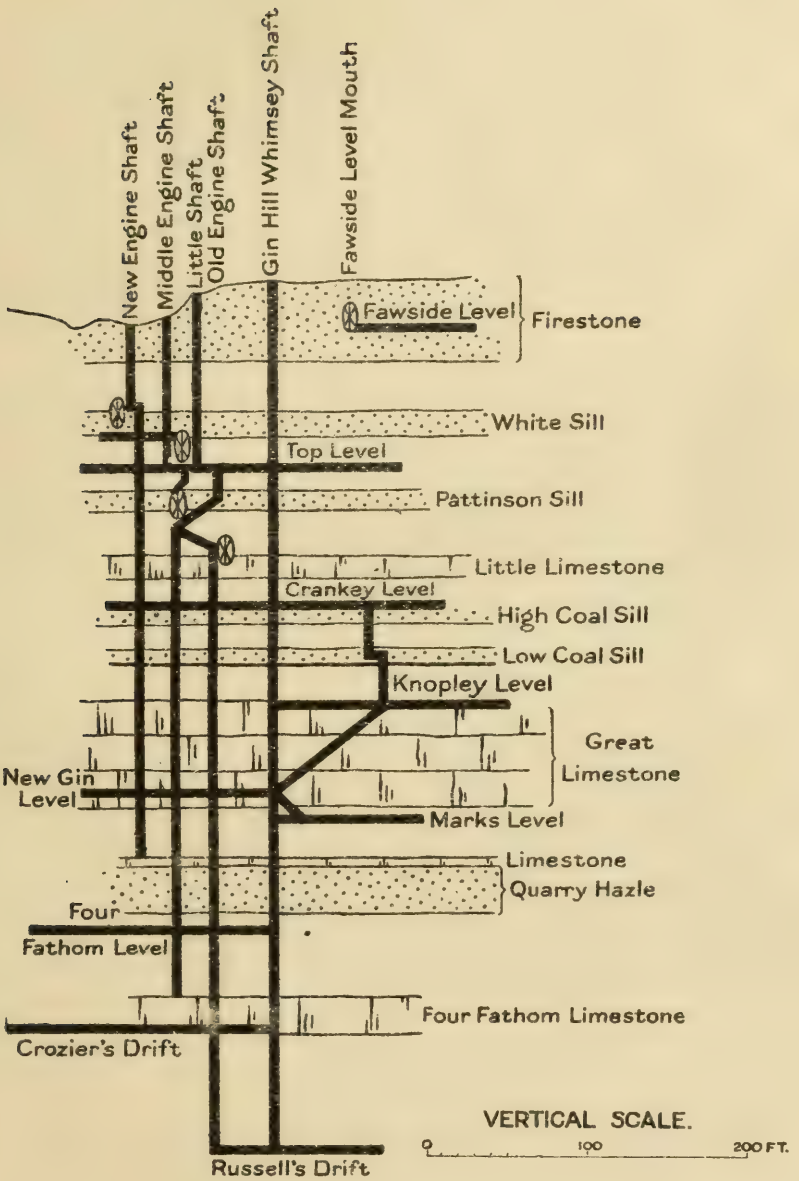
The Northumberland workings extend from the county boundary to the Burtree Ford Dyke, a distance of $1\frac{1}{2}$ miles and are marked by a large number of old shafts. The oldest part of the workings are those west of Allenheads. The principal shaft, the Gin Hill Shaft, situated near to the W.B. Lead Company's offices in the village of Allenheads, has been sunk on the Allenheads Old Vein to a depth of about 90 fthms.

The section of this part of the mine is reproduced (Plate 10), as it indicates the position of the levels and of the underground water-wheels. At Coe or Old Whimsey Shaft, lying to the east of the Burtree Ford Fault, the Top Level passes below the Great Limestone and the Crankey Level below the Four Fathom Limestone. The latter level ends here (*see* Plate 11), but the Top Level was carried forward through the fault, with the result of bringing a great amount of water into the mine. The strata rise to the west gently throughout the greater part of the workings, but more steeply as they approach the Burtree Ford Dyke, so sharply indeed close to the dislocation that the Great Limestone itself comes to the surface. Hence those levels that run east from Gin Hill Shaft cross an ascending sequence so that finally the Top Level lies above the Top Coal Sill, the Knopley Level in the plate above the Great Limestone and Marks Level in the Great Limestone itself. The levels that run westward pass rapidly into lower beds as they approach the Burtree Ford Fault. The Crankey and Four Fathom Levels have been carried according to existing plans as far as the Old Whimsey Shaft (Plate 11), the latter level running for most of its course in the limestone from which it gets its name. The Horse Track near the Gin Hill Shaft is a winding inclined way, leading down to the New Gin Level and constructed for horse-traction.

The veins to the south have been reached by Peter's Level, Fawside Level (that has its adit on the east side of the village and runs above the Firestone) and a number of cross-cuts.

Levels traversing Henry's Vein run between the Slate Sills and in the Firestone, Great Limestone, Quarry Hazle and Four Fathom Limestone. In the other veins they are confined almost entirely to the Great Limestone. The workings in Henry's Vein are stated to have been carried to within 80 fthms. of the Weardale workings in the same vein which has been worked north-eastwards from Wearhead under the name of the Bracken Sike Vein.

The mines were partially drained by levels, but some necessary pumping was performed by four underground water-wheels installed in shafts (*see* Plate 10) at Allenheads village



SECTION OF THE GIN HILL SHAFTS, ALLENHEADS.

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and turned by the same stream. The water was raised to the Haugh Level above the Little Limestone and carried into the East Allen. The level is of some interest on account of its age, having been constructed by Sir William Blackett at the end of the 17th Century. It runs northwards for upwards of a mile and reaches the surface by the side of the river near Peas Meadow. Its course is marked by a series of ventilating shafts.

An interesting system was formerly in vogue in East Allendale whereby water was economically used for the purposes of the mines. The following notes have been abstracted from an account preserved in W.B. Lead Company's Offices.

The value of the water in East Allendale as applied to machinery then (about 1870) in use may be fairly estimated at 500 h.p. The available power from the rainfall, which is recorded as averaging 49 inches a year between 1841 and 1870, may be estimated at 800 h.p.

The water was collected in the reservoirs listed below. The first-mentioned is in Rookhope, but the others are within the East Allen drainage.

Name of Reservoir.	Area in Sq. Feet.	Capacity in Gallons.	Height above Sea Level in Feet.
Corbet Mea - - - -	172,334	8,000,000	1,614
East End - - - - -	44,921	2,238,000	1,515½
Spring House - - - -	39,476	1,844,000	1,516
School - - - - -	16,063	750,000	1,436
Redburn Shield - - - -	9,528	356,000	1,393
Byrehope - - - - -	351,475	16,320,000	1,450
Smelt Mill - - - - -	29,403	916,000	1,220
Dodd - - - - - -	309,004	11,550,000	1,432
Swinhope High - - - -	193,360	18,319,000	1,376
,, Low - - - -	17,152	904,000	1,282

The water collected in Corbet Mea Reservoir was taken down the Corbet Mea Shaft and along the level in pipes to the high and low underground engines, and from these was discharged into Fawside Level. It flowed along this to Allenheads dressing floors where it was joined by water exhausted from the surface-engines and from other sources. After being used for washing purposes it was taken by a shallow adit to a point immediately under Allenheads Village and thence conveyed in succession over the four underground water wheels referred to, from which it passed away by the Haugh Adit to the East Allen nearly 1¼ miles below Allenheads. There it united with the water obtained from the Smelt Mill and Dodd Reservoirs and with that used at Allenheads Smelt Mill. Between here and Allendale Town the river was diverted at various points by races so as to pass over the water-mills at Breckton Hill, Sifton, and Holmes Linn Shafts (two wheels at each shaft) and also to operate four corn-mills. It was finally

led to the Allen Smelt Mill by an artificial channel, and then discharged into its natural course.

Possible Reserves.—Although the veins lying under Allenheads have been extensively worked between the Firestone and the Four Fathom Limestone, the flats and strings so largely developed there probably still contain some ore. Henry's Vein also, according to a report dated 1888, has been worked out in the Great Limestone, and a section indicating the extent of the workings confirms this. Some ore still remains unworked in the higher sills and in the beds below the Great Limestone. Miners who have worked in the vein speak of the flats as being still intact at the west end of the working where the mine last saw activity.

The east end of the Allenheads Mine with its enormous development of flats must still carry some reserves, and exploration carried further east (in the county of Durham) may prove sound productive ground.

Swinhope Mine.

This mine, situated in the small valley of that name on the western side of East Allendale, 2 miles N.W. of Allenheads, stands upon the Swinhope Vein, which, under the name of Barney Craig Vein runs through West Allendale. The workings are in communication with those in the western valley, but the mine possessed its own plant and dressing floors. This part of the vein has been little worked during recent years, although the Vieille Montagne Zinc Company, who have held the lease of the vein since 1896, employed a few men in Swinhope Mine for a short time after acquiring it.

WEST ALLENDALE.

The veins in West Allendale all carry barytes or witherite, except those in the extreme south; these contain blende in place of barium-spars. The mines are:—

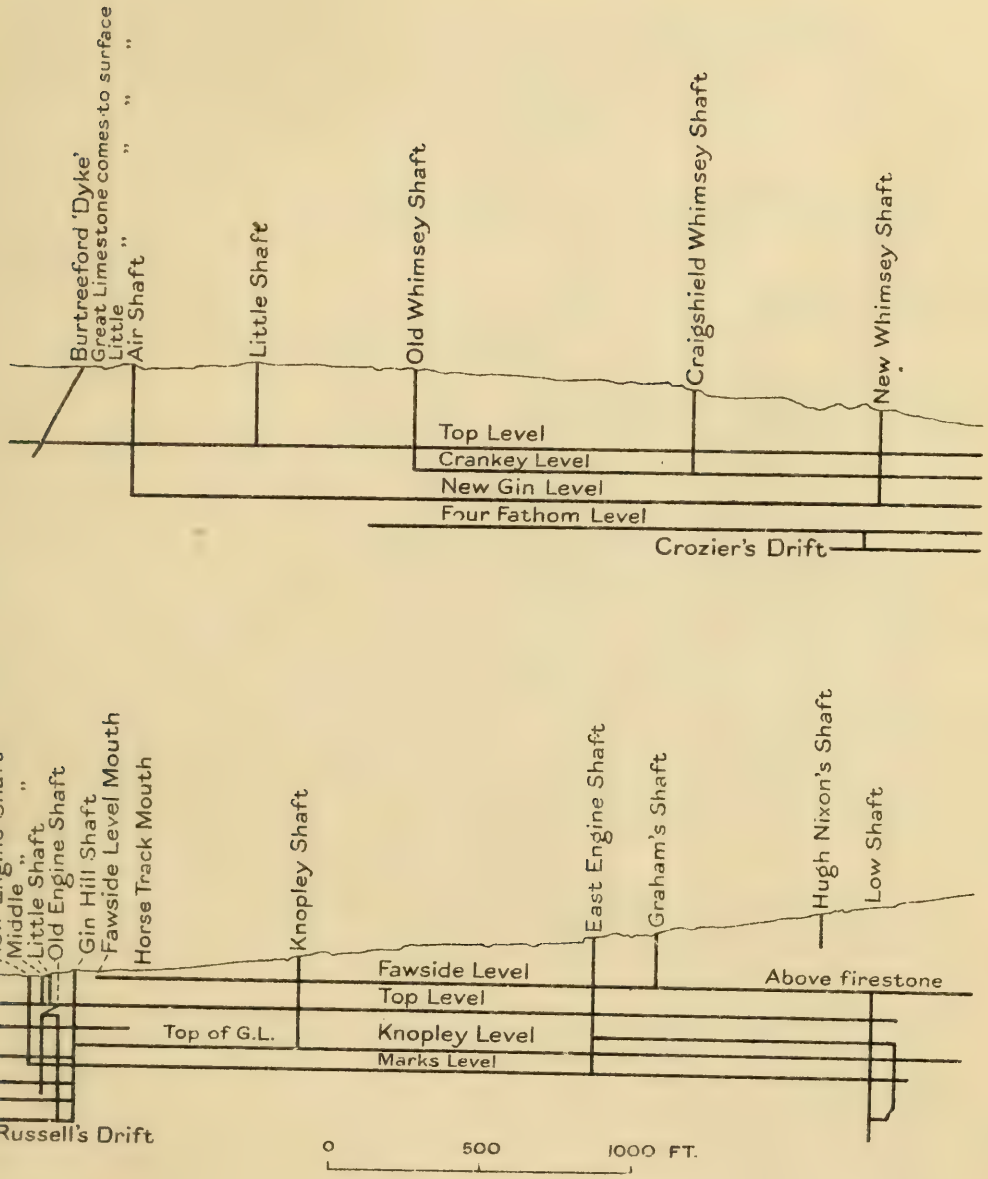
Ouston, Longcleugh, Keirsleywell Row, Mohopehead, Heartycleugh, Coalcleugh, with its subsidiary workings at Wellhopehead, Scraithehole, and Barney Craig.

Ouston Mine.

Maps.—One-in. (Geological) Old Series, Sheet 106 S.E. New Series, Sheet 19. Six-in. (Geological) Northumberland, Sheet 106, N.E.

Site.—The mine lies on the west side of the West Allen, nearly opposite to Ninebanks and about 220 yds. N.W. of Ouston farmstead.

The Ouston Vein (E.N.E.-W.S.W.), worked about the middle of the 19th century, is the most northerly of the veins wrought in West Allendale. No information concerning the mine was obtainable, but the spoil-heaps contain galena and barytes.



SECTION OF THE ALLENHEADS MINES.

Returns to a total amount of 284 tons under the name "Whitefield Mine" are found in Hunt's Statistical Tables between the years 1848 and 1853. The mine referred to may have been the Ouston or Longcleugh.

Longcleugh and Keirsleywell Row Mines.

Maps.—One-in. (Geological) Old Series, Sheet 106 S.E. New Series, Sheet 19. Six-in. (Geological) Northumberland, Sheet 106 N.E.

Site.—Near the village of Keirsleywell Row, 1¼ miles S.S.W. of Ninebanks between the Whitewalls and Mohope Burns.

The veins wrought in these mines trend E.N.E.–W.S.W. and are cut off to the west of the village by a belt of north-and-south cross veins.

The lead was chiefly obtained from the Great Limestone and was associated with witherite and barytes. The mines have long been idle.

Longcleugh Mine.—(This mine must not be confused with that of the same name near Nenthead).

Three Longcleugh Veins have been wrought, namely, the North Vein (called on one old plan the Walton Vein) which throws down 31 ft. to the north, the Middle Vein throwing down 44 ft. to the south and the South Vein with a downthrow to the north of 41 ft. Minor strings were also proved, and moreover the cross-veins are here reported to have produced ore. A note on an old plan dated May 30th, 1846, and initialled "G. H.," states that no vein or string running in an east-and-west direction ever produced ore in sufficient quantity to pay, except the Walton Vein, which, in a drift 6 ft. wide by 6 ft. high produced, as estimated, 16 bings (6⅔ tons) per fthm., but that the ore raised from the cross-strings amounted to nearly 1,300 bings (520 tons). It is possible that the east-and-west veins had been already worked.

The witherite from this mine is reported to have been of particularly good quality, containing 96–97 per cent. of barium carbonate.

The adit level enters the Middle Vein from the south, and then follows it westward for 350 fthms. or so. Between the Cross Veins the level explored the ground to the north and south. The North Vein and South Vein were opened out but only for a short distance from a level in the Keirsleywell Row East Cross Vein.

Keirsleywell Row Mine.—There are two veins, the Keirsleywell Row North Vein and the Keirsleywell Row South Vein, separated by little more than 50 yds. and letting down the strata between them 9 ft. Old waste-heaps and still older "hushes" are seen on the west side of the village.

A level, the mouth of which is situated east of the village, has been driven along the side of the North Vein for a quarter

of a mile, and is continued through the Cross Vein for another 150 fthms. Within the belt of Cross Veins a north-and-south branch of the level has been carried as far as Fairplay, a distance of some 350 fthms., and the mine is connected with the Mohopehead Mine by Keirsleywell Row Level.

The two veins are reported to have yielded a great quantity of lead ore from the Great Limestone, but the Cross Veins may be inferred from old plans to have been quite unproductive [*cf.* Longcleugh Mine].

The mine lies at the boundary of the Allendale property, Longcleugh and Ouston Mines being in the Whitfield estate.

Mohopehead Mine.

Maps.—One in. (Geological) Old Series, Sheet 106 S.E. New Series, Sheet 19. Six-in. (Geological) Northumberland, Sheet 106 S.E.

Site.—2 miles S.W. of Ninebanks, near the farmstead of Mohope Head.

There are two veins trending N.E.–S.W., the Mohopehead North Vein and the Mohopehead Sun Vein. The Sun Vein, which has a throw of 5 ft. to the south, was worked as late as 1870. A level was driven along it at the base of the Great Limestone for more than ½ mile, and encountered two or three Cross Veins, one of which would seem from its position to be the Heartycleugh Cross Vein.

The adit-level enters the veins from the south and has its mouth in Scabby Cleugh, about 150 yds. south of Mohope. From it an exploration, called the Keirsleywell Row Level, has been driven in the Quarry Hazle. This is a mile in length, and connects Mohopehead Mine with the Keirsleywell Row Mine; it proved several veins in the vicinity of Fairplay.

Heartycleugh Mine.

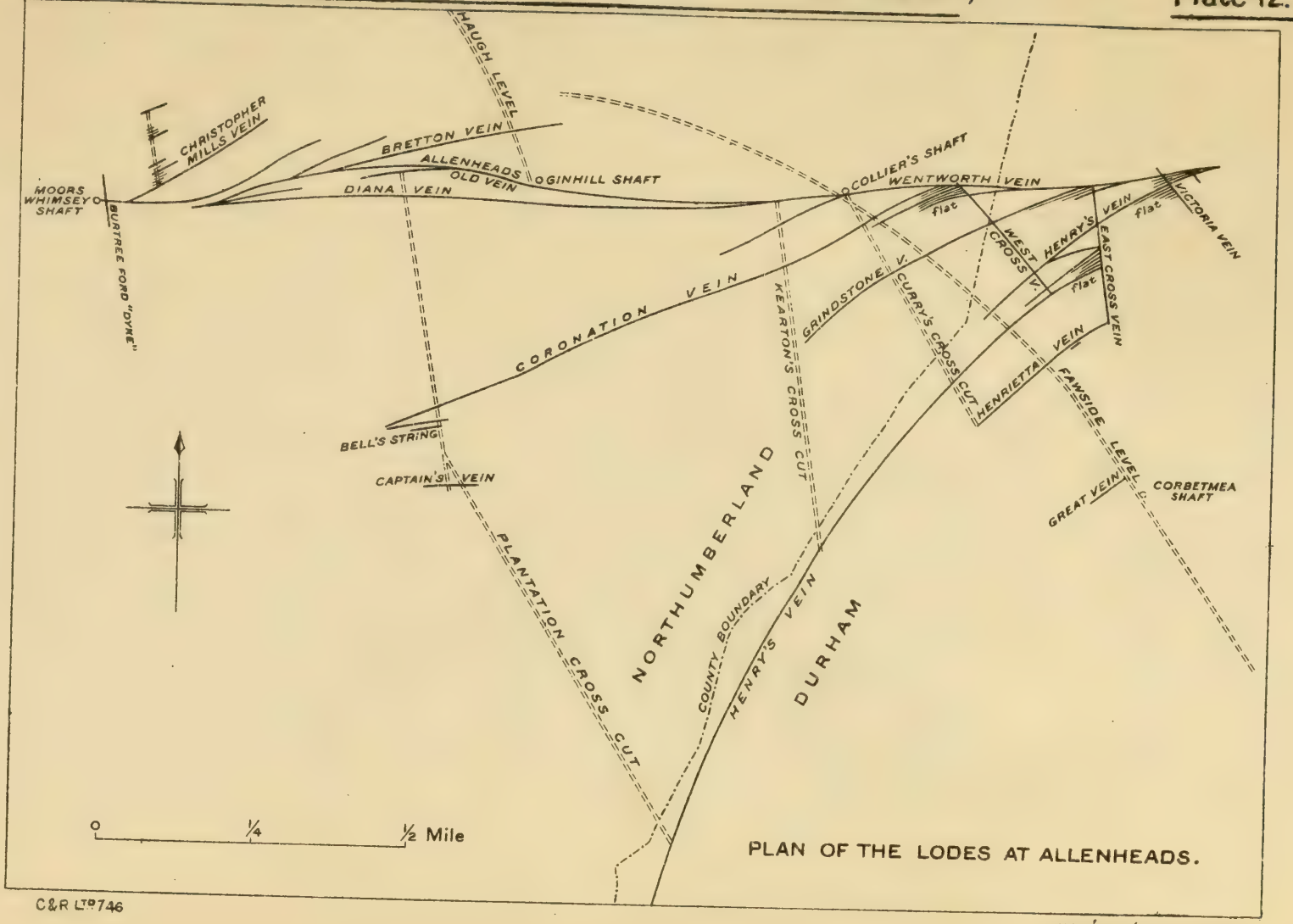
Maps.—As for Mohopehead Mine.

Site.—The level-mouth is situated in Heartycleugh on the west side of Mohope Burn, about 2¾ miles S. by W. of Ninebanks.

A N.E.–S.W. vein running parallel with the Cleugh intersects a long N.W.–S.E. vein near the head of the valley. The latter vein, according to old plans, runs from Wellhope to Mohope and has two branches diverging from it south of its intersection by the N.E.–S.W. vein. Two other veins are shown as joining it from the S.W., near Black Cleugh. The workings were confined to the Great Limestone.

Blackpool Bridge Level.

To the east of these mines between the River West Allen and the long north-and-south Great Cross Vein which runs



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parallel to it, an exploration-level has been driven southwards for ¾ of a mile. The level-mouth lies 200 yds. south of Blackpool Bridge and two-thirds of a mile south of Ninebanks. At least four veins were proved, three on the west —the Stag Rake Vein, an unnamed vein, and the Bates Hill Vein, and one on the east of the fault—the Greenleycleugh North Vein. The forehead, according to an old plan, stands in the last-mentioned vein, while Greenleycleugh South Vein lies beyond. No information could be gleaned concerning any of these veins.

It was in this neighbourhood that Matthew Bee had his mines in the 16th Century (*see* p. 55).

Wellhope Low Level.

This, a third exploration-level, is situated south of Heartycleugh Mine. It is 700 fthms. long and has been driven southwards in the Great Limestone by the side of the Wellhope Burn. Its mouth lies 300 yds. E.N.E. of Wellhope, and on an old plan signed "T. Sopwith" it is shown as cutting a number of N.E.–S.W. veins and strings (one of which was 5 ft. wide and throws down the strata 14 ft. to the south). The vein is crossed by a north-and-south vein. To the north of the veins there was found a "belt or patch of debris" 80 ft. across but effecting no displacement. An "east-and-west" vein, bearing in the direction of an old shaft and a "hush" that lie west of the level, was cut near the forehead. No other veins are indicated on the plan, though the High Raise Vein ranges for this level.

Barium sulphate and carbonate occur in the spoil-heaps.

The Scraithehole, Barney Craig and Coalcleugh Mines.

These were by far the richest and most extensive mines in West Allendale. They were among the oldest on the Allendale estate and were being worked long after the other mines in the western valley had been abandoned.

The great veins upon which they were situated—the Scraithehole, the Low Coalcleugh and the High Coalcleugh or Whitewood and the Barney Craig Veins all continue into the Nent Valley and are being worked by the Vieille Montagne Zinc Company both in Cumberland and Northumberland. An account of them is therefore deferred to pp. 72, &c.

The ore raised from the three mines was brought by long levels near to the same place and dressed on the same floor a mile north of the village of Coalcleugh, 8 miles by road from Allendale Railway Station.

John Wallis[1], in alluding to Coalcleugh, remarked that "it is said to be the deepest mine in England, 100 fathoms, a subterraneous waggon way of a mile in length leading to its ostium."

Summary of Returns.

From 1845 to 1881 the outputs of the East and West Allendale and Weardale mines (*i.e.*, the whole of the Beaumont Mines in Northumberland and Durham) were returned together. During this period the greater part of the ore was raised from Weardale Mines, and Allendale furnished no independent returns except for the 5 years, 1876 and 1878–1881. Only the amounts of lead-ore, lead and silver therefore need be given.

Lead-ore returned between 1845 and 1881, 37 years	375,073 tons.
Lead returned between 1845 and 1881, 37 years	287,957 „
Silver returned between 1853 and 1881, 29 years	1,147,449 ozs.

Allendale W.B. Mines, i.e., *East and West Allendale.*

The ore raised was chiefly from Allenheads.

Lead-ore returned between 1882–1896, 15 years	6,195 tons.
Lead returned between 1882–1896 (5 years missing), 10 years	2,987 „
Silver returned between 1882–1896 (1890 missing), 14 years	25,138 ozs.
Metallic lead in ore	74·5 per cent.
Silver per ton of lead	5 ozs.

East Allendale. Sipton Mines.

Lead-ore returned for 1913–1918, 6 years	1,300 tons.
Lead returned for 1913–1918, 6 years	984 tons.
Silver returned for 1913–1918, 6 years	5,200 ozs.
Metallic lead per ton of ore	75·5 per cent.[2]
Silver per ton of lead	5 ozs.

"West Allendale Carrshield."

Veins worked by the Vieille Montagne Zinc Company.

Lead-ore returned for 1899–1918, 20 years	6,137 tons.
Lead returned for 1899–1918, 20 years	4,380 „
Silver returned for 18 years	34,096 ozs.
Metallic lead in ore	71 per cent.
Silver per ton of lead	8 ozs.

Westgarth Forster, in his "Treatise on a section of the Strata &c.," 1821, p. 420, states that the average produce of the Allendale Mines between 1800–1821 was 8,000 bings (3,200 tons) per annum.

The summary account sheets of the W.B. Mines record an output of 46,760 tons of ore from Allenheads Mines.

	Tons.
1868–1870 "Leasehold" (veins within Durham, Henry's Vein, &c.)	18,087
"Freehold" (vein within Northumberland)	4,841
1871–1883 (June) "Lease and Freehold"	23,632
Total	46,560

The amounts recorded are evidently those of crude ore, not dressed ore.[3]

[1] "The Natural History and Antiquities of Northumberland," 1769, Vol. I., p. 120.

[2] (Percentage of lead in ore by assay stated as 77–79 per cent.)

[3] Amount of dressed ore returned for 1879–1882, 2,055 tons. Amount of ore raised as recorded by account sheet, 1879–1882, 3,986 tons.

East Allendale. Allenheads.

	Tons.
Zinc-ore returned for 1874–1875, 2 years	29½

West Allendale. Carrshields.

Zinc-ore returned for 1899–1918, 20 years	50,776

THE NENT AND SOUTH TYNE VALLEYS.

The county boundary between Northumberland and Cumberland follows the divide between the West Allen and the Nent drainage, and west of this, the course of the Ayle Burn. Most of the region described therefore lies within Cumberland.

The higher part of the Nent Valley lies further within the metalliferous region than does the lower part. In the South Tyne Valley lead has been obtained as far north as Ayle, possibly as far as Barhaugh ; that is, as far north as it is found in the two Allendales and the Derwent Valley.

The succession of the strata in the Nent Valley from the Fell Top Limestone to the Slaty Hazle is shown by the following section. Still lower beds, below the Jew Limestone, are illustrated in Plate 13.

Rampgill Shaft[1] (part of).

	Fms.	Ft.	Ins.
FELL TOP LIMESTONE	0	4	6
Hazle	2	0	0
Plate	5	0	0
Hazle	1	3	0
Plate	2	0	0
Hazle	2	0	0
Plate	1	1	0
HIGH SLATE SILL	4	0	0
Plate	1	1	6
LOW SLATE SILL	3	3	0
Plate	3	4	0
FIDDLER'S SILL	2	3	0
Plate	5	0	0
Ironstone and Coal	0	4	6
FIRESTONE	5	0	0
Girdle beds	11	0	0
PATTINSON'S SILL	2	0	0
Plate	4	0	0
LITTLE LIMESTONE	1	0	0
White Hazle	0	5	0
Plate	1	3	0
HIGH COAL SILL	2	1	0
Plate	1	0	0
LOW COAL SILL	2	0	0
Plate	4	2	0
GREAT LIMESTONE	10	3	0
TUFT (Horse Level)	1	4	6
Plate	2	5	0
Limestone post	0	1	3
QUARRY HAZLE	5	0	0

[1] "An Account of the Strata of Northumberland and Durham as proved by Borings and Sinkings," 1910, Supplementary Vol., p. 13.

	Fms.	Ft.	Ins.
Plate	5	3	0
Till bed	0	4	0
FOUR FATHOM LIMESTONE	3	4	0
Plate	0	2	0
NATTRASS GILL HAZLE	3	2	0
Eleven Fathoms plate	11	0	0
THREE YARDS LIMESTONE	1	4	4
SIX FATHOMS HAZLE	3	3	0
Plate	4	0	0
FIVE YARDS LIMESTONE	2	0	0
SLATY HAZLE	5	0	0

This section includes all the productive sills of the neighbourhood. The beds are all exposed within the valley, at the head of which the Millstone Grit forms an outlier on Killhope Law, while the Scar Limestone outcrops at the foot, near Alston.

The alternation of hard limestones and sandstones with softer shales gives rise to a conspicuous terracing of the hillsides.

On the northern side of the Nent Valley the veins are separated into the Nenthead and Blagill groups by an interval of unproductive ground. Moreover, a belt of long cross-veins traverses the valley, intersecting the former group but running north of the latter.

In the South Tyne Valley, due north of the Blagill group, are the Ayleburn Veins, and north of these again there are some indications of lead veins in the neighbourhood of Barhaugh Burn.

The whole of the district, including the Ayle estate but excluding Barhaugh, forms part of the Manor of Alston Moor owned by the Greenwich Hospital. The metalliferous mining within the manor is now in the hands of the Vieille Montagne Zinc Company[1], who acquired the mines in 1896 or during the succeeding years. Many had been abandoned when taken over, but after the erection of new plant, the pre-war annual output of the Vieille Montagne Mines in Cumberland and Northumberland was brought up to about 2,000 tons of lead and 10,000 tons of blende, *i.e.*, 60 per cent. of the total zinc-ore raised in the United Kingdom. The mechanical power is supplied by a simple but efficient system of compressed air, and the dressing plant installed at Nenthead is the most modern and extensive of its kind erected in the British Isles.

The Nenthead Smelting Mill was erected by the London Lead Company about 1746 and was in use until 1898. There was also a smelting mill near Blagill erected at the beginning of the 18th century[2], but this has long been dismantled.

[1] The Vieille Montagne Zinc Company—a Belgian firm—was established in 1837 and owns important mines and works in many parts of Europe and in North Africa. The production of spelter by the company prior to the war approximated to 100,000 tons annually.

[2] W. Wallace, "Alston Moor: its Pastoral People: its Mines and Miners," 1890, p. 154.

The valley has been explored underground for almost its whole length by the long Nentforce Level, supplemented by the Rampgill Shaft. Both produce evidence that, in this valley at any rate, the greater part of the ore lies above the natural drainage-level. A short account of these two important trials is given before proceeding to discuss the veins and mines.

The Nentforce Level.

The Nentforce Level was the first of the long exploration-levels to be constructed in the Northern Mining Field. It was begun in 1776 by the Commissioners and Governors of the Greenwich Hospital, according to the plan and under the direction of John Smeaton. The prosecution of the scheme occupied a great number of years.

It runs from Alston to Nenthead, a distance of 4½ miles, its mouth lying near to Alston Railway Station, immediately below the waterfall from which it takes its name, and its forehead standing beyond Brewery Shaft. Its general dimensions are 9 ft. high by 9 ft. wide, but they vary according to the nature of the strata traversed, in some places the level being as much as 20 ft. high and 16 ft. wide.[1] The level is navigable for a great part of its course, and a voyage underground was at one time a favourite diversion of both natives and visitors[2]; moreover, if Sopwith is correct, it was the first level in which cast-iron rails were used in place of wooden ones.[3]

The level runs in the shale underlying the Scar Limestone for about 1,600 fthms., and then, meeting a sharp upward fold of the strata, passes into lower beds. At Lovelady Shield a vertical rise of 35 fathoms was constructed, and the level continued in beds above the Four Fathom Limestone. At the Brewery Shaft it is running in the Slaty Hazle. The gradient varies slightly, but is small throughout.

This great level failed to prove many new veins, and the veins that it did cut were unproductive at that low random. Its construction, however, has been more than justified by its efficiency in draining the mines along the whole of its 4½ miles of length.

The Rampgill Shaft.

This shaft (*see* Plate 13) was sunk upon the vein of the same name close to the boundary of the royalty. It reached an alternation of thin sandstones and shales underlying the Scar Limestone, 62 fthms. below the Horse Level. From the foot a cross-cut was made to the vein, and the Vieille Montagne Zinc

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[1] Thomas Sopwith, "An Account of the Mining District of Alston Moor," &c., 1833, p. 31.

[2] *Ibid.*, p. 31.

[3] *Ibid.*, p. 118.

Company have followed this for another 55 fthms. by means of an inclined shaft reaching the second limestone below the Tynebottom Limestone—the 12th or Little Limestone[1] of Westgarth Forster's Section. During the process of sinking, the vein was explored by means of various cross-cuts, and these proved it to split up into numerous strings. In the bottom cross-cut siderite and calcite, but no lead ore, were found. The inclusion of the section of the shaft from the Horse Level to the foot of the inclined shaft, reproduced in Plate 13, by kind permission of the Vieille Montagne Zinc Company, renders further description unnecessary. The absence of the Whin Sill should be noted; elsewhere in the neighbourhood this intrusion generally occurs immediately below the Tynebottom Limestone, but here it evidently occupies a much lower position, if it has not died out altogether.

The vein, it may be added, is worked down to the Slaty Hazle, 45 fthms. below the Horse Level; beyond this it may be accounted barren.

THE NENTHEAD AND COALCLEUGH MINES.

Maps.—One-in. (Geological) Old Series, Sheet 102 N.E. New Series, Sheet 25. Six-in. (Geological) Northumberland, Sheet 110 N.E. and 111 N.W. Cumberland, Sheets 34 S.E. and 42 N.E. (the latter not geologically coloured).

Site.—Nenthead lies 4½ miles E.S.E. of Alston Railway Station.

Under the general name "Nenthead Mines" are here included operations prosecuted in a large number of veins extending from Longcleugh to Nentsberry, a distance of 3 miles. The workings are connected underground, and are all accessible by level from Nenthead; the veins may, however, have independent means of access, and were formerly wrought singly, or in groups as separate mines.

For the purpose of describing the field it can be divided into three sets of workings, namely:—

(1) The Longcleugh;

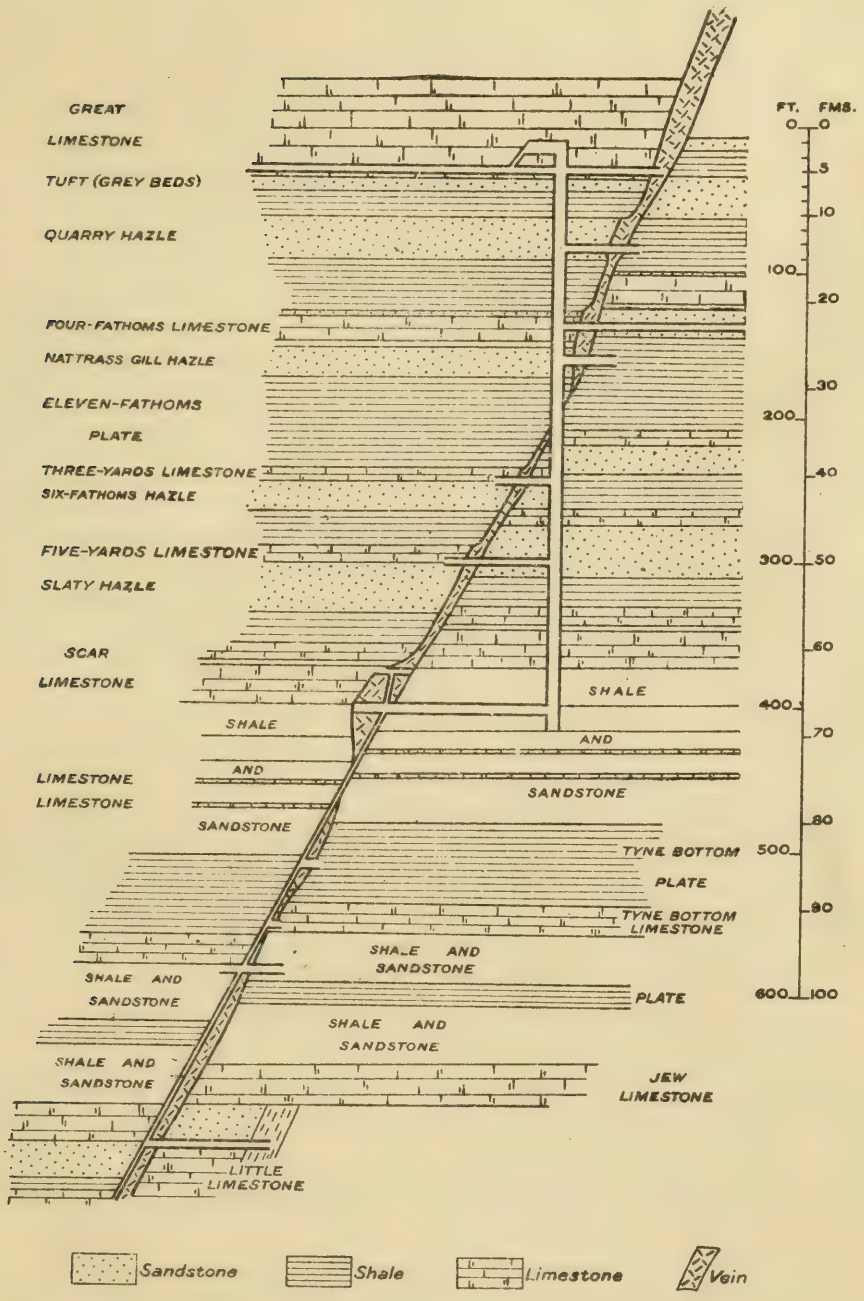
(2) The Nenthead;

(3) The Brownleyhill and Nentsberry.

The first of these lies outside the area covered by this Report, and is therefore left out of account, but included in the description of (2) are the Coalcleugh workings, with which they are connected underground.

The veins at Nenthead (the Rampgill, the Scaleburn, &c.) were acquired by the London Lead Company during the middle part of the 18th century, but not all at the same time.

[1] This must not be confused with the limestone above the Great Limestone so widely known by that name.



SECTION OF THE RAMPGILL SHAFT.

In 1882 that company surrendered the leases of all the mines it held under the Greenwich Hospital.[1] A local syndicate known as the Nenthead and Tynedale Mining Company was then formed to work the mines held by the London Company, and remained in occupation until 1896, when the lease was transferred to the Vieille Montagne Zinc Co. The Brownley Hill and Nentsberry Veins were never worked by the London Lead Company, but by a succession of small local companies. The Alston Moor Mining Company, which had held the mines for some years, was succeeded in 1895 by the Nentsberry Mining Company, and this in its turn by the Lugdale Chemical Company in 1908. The Vieille Montagne Zinc Company acquired the mines in 1914.

For a long period the veins were worked for lead and the zinc neglected, but under the Nenthead and Tynedale Mining Company and the Vieille Montagne Zinc Company, the latter became the more important product. Much of the zinc-ore has been obtained from old workings and even from "deads" used for packing the wrought-out portions of the veins.

The veins, particularly the great lodes, have been largely exhausted of galena, but those parts in which blende was much intermixed were frequently left by the old miners, and the enormous development of "flats" still holds considerable but unknown reserves of both ores.

The average yield of the three veins in working in 1918 was by estimation :—

——	Lead-ore.	Zinc-ore.
	Tons per Fathom.[2]	Tons per Fathom.[2]
Barney Craig Vein - - -	1	1·5
Guddamgill Vein - - - -	1	1
High Raise Vein - - - -	2	1·75

The Cross Veins.

The veins which run in a N.W.–S.E. direction are generally known as "cross-veins." The longer members of the series are :—

Black Ashgill Cross Vein, downthrow 18 to 21 ft., to the S.W.

Cowhill Cross Vein, downthrow 12 to 18 ft., to the S.W.

Carr's Vein, downthrow 44 ft. to the N.E. (Longcleugh), 165 ft. to the N.E. (Nentsberry).

[1] The London Lead Company were the Lessees of nearly all the mines belonging to the Greenwich Hospital. It established itself in the district in 1737.

[2] The fathom generally employed in Cumberland and taken as the basis of the above calculations is the Greenside Fathom, measuring 6 ft. × 6 ft. × 4 ft., and therefore one-third less than the cubic fathom.

Smallcleugh Cross Vein, downthrow 20 to 30 ft., to the N.E.

The Great Cross Vein, downthrow 96 ft. (south of Hangingshaw Vein), to the N.E.

To this series may be added two in West Allendale:—

Coalcleugh West Cross Vein, downthrow 126 ft. (at the Barney Craig Vein), to the N.E.

Coalcleugh East Cross Vein, downthrow 112 ft. (at the Barney Craig Vein), to the S.W.

The situation and relations of the cross-veins are more easily followed from the geological maps than from description. The Great Cross Vein becomes the Guddamgill Burn Cross Vein north of Nenthead, and from this branches the Wellgill Cross Vein. An interesting series of sections through these cross-veins is reproduced by Wallace,[1] who shows them all as normal faults.

Though not generally productive these cross-veins may carry a little lead and zinc in the Great Limestone, particularly near their intersections with the "veins." Carrs and Wellgill may be especially mentioned in this respect, and separate returns of the lead-ore obtained from them have been made (*see* p. 84).

Among the smaller cross-veins mention may be made of the following:—

In the Nent Valley: Fairhill, Patterdale, and Rampgill Cross Veins.

At the Boundary: The Bounder Cross Vein.

In West Allendale: Killhope and Pumpsump Cross Veins.

The Fairhill and Patterdale Cross Veins have produced hardly any ore, but a fair quantity has been raised from Rampgill Cross Vein, the Killhope and Pumpsump Cross Veins, and from the flats associated with the two latter.

The Nenthead and Coalcleugh Veins.

The Rampgill, Scaleburn, and Guddamgill Veins run through the Nent Valley into West Allendale, and the Barney Craig Vein, a branch of the Rampgill, from the county boundary through West Allendale into East Allendale. Hangingshaw Vein lies east of Smallcleugh Dam, Pity Mea and Nenthead Fields Veins in the valley bottom east of the village.

The veins are all reached and traversed by horse-levels running in or below the Great Limestone, the gentle rise of the strata towards the divide, both from the Nent and in West Allendale, permitting a fairly constant horizon to be maintained. Slight changes in the dip or faults may cause these levels to run well within the Great Limestone or down

[1] "Mineral Deposits," 1861, Plates VII., IX., XVII., and XIX.

into the Quarry Hazle, and occasionally for short intervals beyond these limits, *e.g.*, the Barney Craig Level, in traversing the ground between the Coalcleugh Veins (*see* p. 78), but generally they run in the Tuft and plate between the Great Limestone and the Quarry Hazle.

Levels from Nenthead.—The Rampgill Level forms the main entrance into the Rampgill and Scaleburn Veins. Its mouth is situated close to the river, between the old smelt-mill and the present dressing-floor. It follows what is possibly a continuation of the Scaleburn Vein for a short distance, but branches before reaching the Smallcleugh Cross Vein, one branch running into the Scaleburn Vein and the other into the Rampgill.

The Bloomsberry Level gives access to the Guddamgill Vein, and leads into the Wellgill Level, which runs along the Guddamgill and Wellgill Cross Veins from the Guddamgill Vein to the High Raise Vein. From the Wellgill Level a branch passes along the continuation of the Guddamgill Cross Vein to the Brownley Hill Veins. "Bloomsberry Mine" and "Rampgill Mine" are connected underground by way of the Rampgill Cross Vein.

Levels in West Allendale.—The Barney Craig Level forms the chief entrance into the veins. It runs from Carrshield to Whetstone Mea, a distance of $1\frac{1}{4}$ miles. Through the latter part of its course it keeps parallel with, though a little to the north of, the Coalcleugh East Cross Vein. Branches from it lead into the Low Coalcleugh (Scaleburn) Vein, into the north part of the Whitewood (Rampgill) Vein and into the Barney Craig Vein, following the last-named both to the north and to the south.

Swinhope Level leads into the Barney Craig Vein from East Allendale, and the Dodd Level into Guddamgill Vein from the level traversing the Scraithehole Vein.

The workings in the sills above the Great Limestone were entered by higher levels, the uppermost of which (usually the most important) generally ran upon the Firestone as in the case of the Coalcleugh Level.

Levels and workings below the Horse Levels are reached by sumps.

Flats.—The flats are practically confined to the Great Limestone, and even within that Limestone "flatting" takes place mainly at certain horizons, namely, at 9 ft., 32 ft., and 48 ft. approximately above the base. These positions coincide with well-marked bedding-planes, such as shaly partings; subsidiary flats may, however, occur between the main flats.

These horizontal extensions to the veins are most irregular (*see* Plate 14); they may stretch hundreds of feet from the veins, particularly in regions where strings are abundant, and

may swell out to a thickness of 30 ft. or even more, lenticles of ore and spar alternating with dolomitised limestone.[1]

The Rampgill Vein.

(Whitewood Vein in West Allendale.)

Rampgill is computed to have been the richest vein in Alston Moor, and, at the "general letting" by the Greenwich Hospital in 1736, was retained by the Commissioners and Governors for their own use. They began the horse-level, but after nine years let the vein to Colonel Liddle, who only held it six months. The lease was acquired shortly afterwards by the London Lead Company.[2]

The lode was esteemed of such importance that John Smeaton was employed to survey the mine, and fix the boundary between the Greenwich Hospital and Allendale estates.

The vein has been traced from Nunnery Hill, south-west of Nenthead, to Carrshield Moor, a distance of $3\frac{1}{2}$ miles. South of the Nent its track is conspicuously marked by the deep gash of Dowgang Hush. The vein through this part of its course has been worked at least as deeply as the Great Limestone. It has been worked to some extent through the belt of cross-veins at the bottom of the valley, but with poor result. The richest part is that extending from the Great Cross Vein to its connection with the Barney Craig Vein, a little beyond the county boundary. Wallace[3] estimated that up to 1861, 120,000 tons of lead ore had been raised from the last 300 fthms. within Cumberland.

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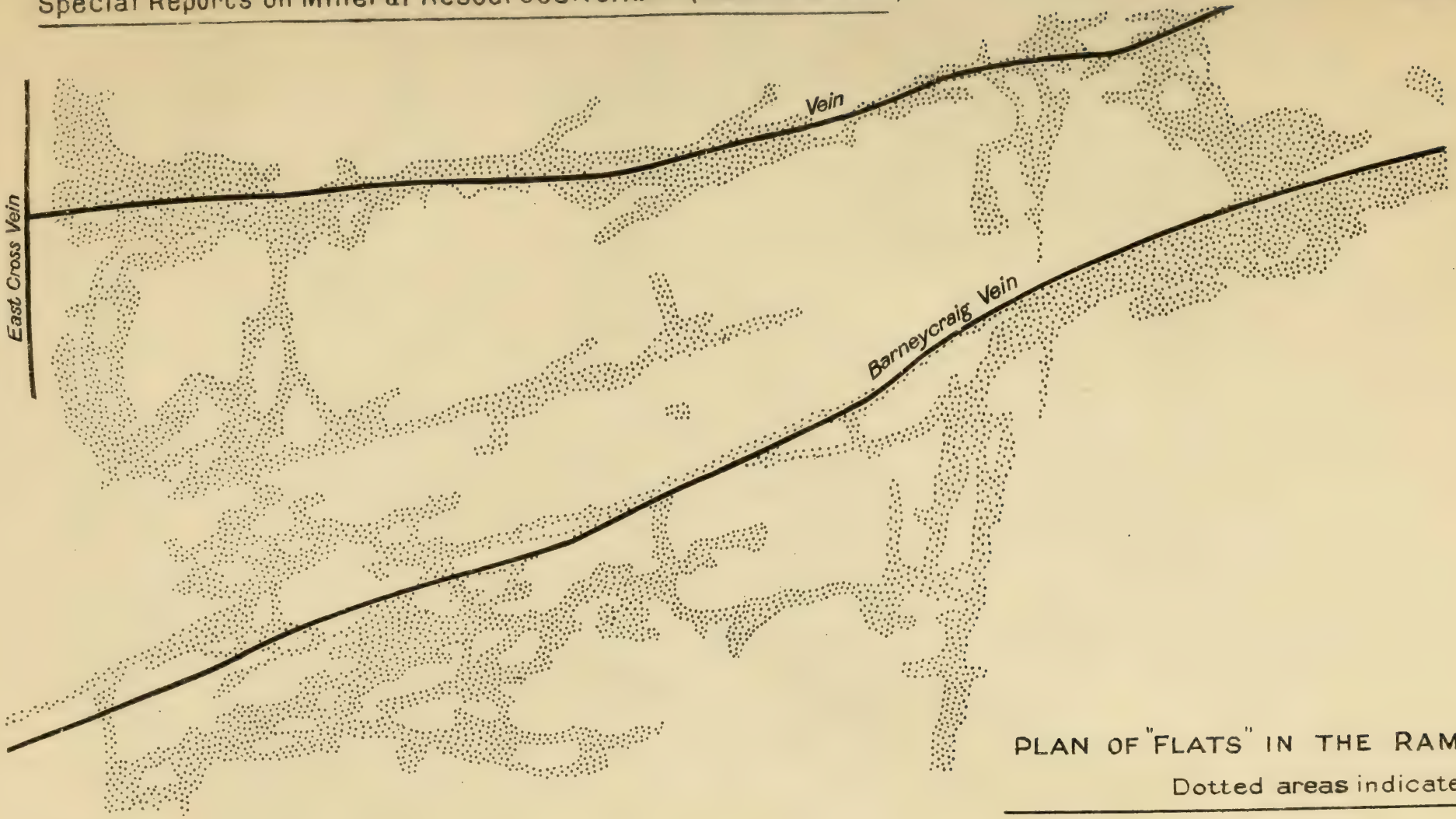
[1] An inspection of the workings at Rampgill showed that these "flats" are metasomatic replacements of the limestone, comparable with the Boltsburn "flats" in Weardale, to the account of which the reader is referred (*see* "Special Reports on the Mineral Resources, Vol. XXVI.—Lead and Zinc Ores of Durham, Yorkshire and Derbyshire, &c." Wallace, so long ago as 1861, recognised their essential nature; he figures an excellent cross-section (Wallace, "Mineral Deposits," Pl. XIII., and pp. 135–136), which "shows the flats as they are usually met with in the Great Limestone stratum. In this instance the west side gradually merges into pure limestone, and the portion most corroded lies near the cross-vein" (the feeder). " . . . . In the formation of flats the quantity of limestone changed or transported from many places is very great. The Small Cleugh flats . . . . do not occupy an area less than 8 acres. They are chiefly situated in the low flat post, which is 15 or 16 ft. thick; consequently in this post alone not less than 5,000,000 cub. ft. of limestone has undergone decomposition and rearrangement of its particles, besides the large quantities which have undergone similar changes in the middle of high flats." An instructive plan of the Handsome Mea (Great Cross Vein) flats, adjacent to Small Cleugh, is given by Wallace (*loc. cit.*, Pl. XIV.). These deposits have long been wrought out, but work is still proceeding in the still more extensive "flats" off the Barney Craig and Whitewood (Rampgill) Veins; from the diagram, Plate 14, some idea of their curious ramifications may be gained.—R.G.C.

[2] This information was given in some M.S. notes, presumably by W. Wallace, accompanying an old plan of Scaleburn Mine.

[3] "Mineral Deposits," p. 103.



PLAN OF "FLATS" IN THE RAMPGILL MINE

Dotted areas indicate "FLATS"

Scale: 120 ft to 1 Inch

1180.S.SI'41.750. 2'23.

C & R. LTD 746.

The deepest part of the mine lies under the divide, where for about 100 fthms. on both sides of the county boundary the workings lay in the Slaty Hazle, at a depth of about 130 fthms. from the surface. This stratum has not been productive except below the ridge, the Four Fathom Limestone being generally the lowest productive sill; many veins will not repay working below the Quarry Hazle. Rampgill Vein has been worked from the Firestone downwards, and much ore has been obtained from Pattinson's Sill, the Little Limestone and the Coal Sills.

Throughout the rest of its course under Coalcleugh Moor the vein proved much poorer, and between the Killhope Cross String and the Coalcleugh East Cross Vein it is, according to the plans, cut out altogether. It has been proved east of the Coalcleugh East Cross Vein for about 300 fthms.

Rampgill Vein has been described as a wide one (10 to 12 ft. in the Great Limestone) and having a downthrow to the N.W. In the Nenthead workings the throw is 18 ft., but this increases to 36 ft. under Coalcleugh Moor. East of Coalcleugh East Cross Vein, the throw has dwindled to 15 ft., and Wallace asserts that at the eastern end the throw is in the opposite direction. The vein is nearly vertical.

At least two sun-veins diverge from the Rampgill Vein within Cumberland; one, according to Wallace, carried barytocalcite in the Grindstone Sill. Immediately north of the Bounder Cross Vein numerous strings branch off the lode, including Hardshins String; these connect Rampgill with Barney Craig.

The Rampgill Vein throughout forms extensive flats, but more particularly where it is joined by the sun-veins and where, north of the Bounder Cross Vein, it is connected with the Barney Craig Vein. The ore raised during latter years has been obtained chiefly from the flats and from the lower sills.

Barney Craig Vein.

(Swinhope Vein in East Allendale.)

The Barney Craig Vein has been followed from a point 170 yds. north of the county-boundary into Swinhope Valley on the east side of East Allendale, a distance of $2\frac{1}{2}$ miles. If the lode worked at St. Peter's Mine is a continuation, as is probable, the vein is at least $4\frac{1}{2}$ miles in length. It is connected with the Rampgill Vein by Hardshins String, and south of this connection it is assumed to splay out. It may be observed, however, that the vein is in line with the second Rampgill Sun Vein that leaves Rampgill Vein south of the Bounder Cross Vein.

The vein has been the most productive of those under Coalcleugh Moor, and it would seem that the greater part of the lode lodged in Rampgill Vein ran into this line of fracture instead of persisting along the same fault through

West Allendale. It has been much worked between the Firestone and Quarry Hazle, and to a lesser extent in the Four Fathom Limestone.

Barney Craig Vein passes uninterruptedly through all the cross-veins that it meets—the Killhope Cross String, the Pumpsump Cross Vein, and the two Coalcleugh Cross Veins; but within the strip of strata let down between these two N.W.–S.E. faults it is unproductive.

Between Coalcleugh Level and Coalcleugh West Cross Vein a large number of strings, including the Barney Craig Sun Vein, split off the lode, and associated with these, but more particularly on the north side of the Pumpsump Cross Vein, is a great spread of flats. A still more extensive development of flats is met on the north side of Coalcleugh East Cross Vein, extending along that vein itself to beyond the "Engine String" east of the Whitewood Vein. Flats also occupy the ground intervening between the Barney Craig Vein and the Whitewood Vein, and stretch for some fathoms east of the former, where they are fed as before by strings.

The workings in the Killhope Cross String encountered another vein, the New Vein, about 150 fthms. S.E. of the Barney Craig Vein and have followed it in the Great Limestone for some 250 fthms. to the county boundary.

The portion of the Barney Craig Vein that lies within the Swinhope Valley is by no means so productive as that under Coalcleugh Moor. In Swinhope a north vein also has been proved, and has been worked for a short distance. Barney Craig Vein as seen in the Great Limestone is a wide belt of fracture varying from 12 to 26 ft., presenting an open network of vein-strings of blende. The galena occurs in intermittent ribs and in pockets, and as small strings, flakes and isolated crystals disseminated throughout the blende. The vein is best described as brangled.

In Swinhope it carries fluorite as well as blende, but the spoil-heaps largely consist of ferruginous rock impregnated with blende.

The vein is entered from Cumberland by way of the Ramp-gill Level and by a flank level from this driven in Hardshins String; access is gained from West Allendale by the Barney Craig Level and from East Allendale by the Swinhope Level.

The Swinhope Level, which enters the vein in Pattinson's Sill, reaches the base of the Great Limestone at Swinhope Whimsey Shaft and has been driven south-westward under that bed until it reaches the West Allendale workings. Thus, the vein is traversed its whole length by a horse-level, which, except in the ground let down between the two Coalcleugh Cross Veins, is confined to the beds lying between the base of the Great Limestone and the Quarry Hazle.

Between the Cross Veins, it runs above the Upper Slate Sill; a sump was sunk in the Great Limestone, but even in that

bed the vein was found unproductive in spite of its richness on both sides of this small rift.

The Scaleburn Vein.

(Low Coalcleugh Vein in West Allendale.)

This vein is neither so rich nor so wide as the Rampgill, but it has nevertheless been extensively wrought in the Nent Valley and in West Allendale. The Cumberland portion was acquired by the London Lead Company about 1756.

It has been followed from the Great Cross Vein to Coalcleugh West Cross Vein, a distance of 2 miles. South of the Great Cross Vein its course is uncertain. Wallace maintains that it splits off the Rampgill Vein near Fairhill, *i.e.*, between the Great Cross Vein and Smallcleugh Cross Vein, but others believe that it is a continuation of the vein that diverges from the Rampgill Vein near the head of Dowgang Hush. The vein has a pronounced hade to the south-east, but a throw of only 6 ft. at Gillgill and of 14 ft. to the N.W. in West Allendale near the county boundary.[1]

The richest portion of the vein in Cumberland is stated to lie 30 fthms. on both sides of Gillgill.[2]

In this ground it is asserted the vein has been worked out in all strata between the Pattinson's Sill and the Quarry Hazle, and has produced much lead from the Girdle beds and the intervening beds of plate under the Firestone. The Four Fathom Limestone, however, contains here little or no lead. In West Allendale the vein has also been worked from the Firestone down into the Quarry Hazle and tried in the Four Fathom Limestone. Access to the vein from Nenthead is gained by means of a branch from the Rampgill Level, from Carrshield by one of the branches of the Barney Craig Level, which runs as a flank level for some distance before it enters the lode near Far Houses. The vein passes under the village of Coalcleugh where there are indications of old surface workings. South of Coalcleugh it gives off from both sides a fan of strings, and further north a wide development of flats is encountered, extending from the second of two small cross-veins that intersect it near Far Houses, to the Coalcleugh West Cross Vein, where it ends.

Guddamgill Vein.

The continuity of this vein with the Greengill Vein has not been proved, but appears probable. It has not been worked on the south side of Wellgill Level, but has been followed by a horse-level under the Great Limestone to the county boundary, and the workings have now been advanced some little distance into Northumberland.

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[1] According to the Six-inch Geological Map.

[2] Notes on Scaleburn Mine assumed to have been written by Wallace.

The vein is 6 ft. wide, is practically vertical, and produces a downthrow of only 1 to 3 ft. to the N.W. In the Great Limestone it is comparable with the Rampgill and Barney Craig in being a belt of fracture cemented by vein-strings of blende. It exhibits a pronounced tendency to split up into minor strings and to form extensive flats. The galena it carries occurs as well defined but discontinuous ribs, and as horizontal wedges in the flats.

Fine specimens of blende-crystals are to be obtained from this vein, and are found in cavities in the limestone. Wallace[1] refers to the vein as being the richest deposit of blende on Alston Moor. He says that blende "is found plentifully deposited in all the strata between the Pattinson's Sill and the Tuft." Since Wallace wrote it has been proved in, and is now being obtained from, the Quarry Hazle.

200 fthms. west of Guddamgill Vein is Guddamgill Moss Vein, which has only been proved, and there only for a short distance, on the north side of Guddamgill Burn Cross Vein.

The Brownley Hill and Nentsberry Veins.

The Brownley Hill Veins.—This small group of veins lies to the west of Guddamgill Moss Vein and north of Carr's Vein. The N.E.–S.W. veins (mentioned in order from east to west) are:—Brownley Hill Sun Vein, the Blue Black String, Brownley Hill Middle Vein, Brownley Hill North Middle Vein, Brownley Hill Vein, Brownley Hill North Vein.

West of these and running parallel with them at an average distance of 14 fthms. are, according to a recent report upon the mines, six strong strings, all of which have been observed on the Wellgill Level. The Cross Veins are:—Wellgill Cross Vein (eastern part), Guddamgill Burn Cross Vein (western part), Brownley Hill Moss Cross Vein, Jug Vein, West High Cross Vein, Brownley Hill High Cross Vein.

The more easterly veins break up before they reach the Brownley Hill Moss Cross Vein, but the Brownley Hill and Brownley Hill North Veins unite near the county-boundary to form the Wellhopehead or Scraithehole Vein. This persists through West Allendale as far as the River West Allen, a distance of over 2 miles; it passes through the Coalcleugh West Cross Vein near the point at which that vein is assumed to break up, but is displaced some fathoms to the south by the Coalcleugh East Cross Vein. The veins carry galena and blende.

The lodes were worked on the north side of Guddamgill Cross Vein and, to a less extent, between this and the Wellgill Level, but south of that level they have not been followed. Operations were almost entirely confined to the Great Limestone.

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[1] *Op. cit.*, p. 176.

The following information has been obtained from the plans, from a recent report and from statements by Wallace.[1]

Brownley Hill Sun Vein.—The vein is described as being wide and rich throughout, and stoping is said in places to exceed 20 ft. in width. It has been worked northwards from Guddamgill Cross Vein to the boundary of the mining plot, but according to the plans it has not been wrought on the south side of that vein. The report, however, states that it has been opened out for a few fathoms on the south side of the Wellgill Level, but this statement is not confirmed by the plans, which indicate that the Brownley Hill Sun Vein and the Blue Black String are the only ones in the series that have not been worked between Guddamgill Cross Vein and the Wellgill Level.

The Brownley Hill Middle Vein is also reported to have been rich and extensively wrought. The plans indicate the working of flats on its eastern side between the Wellgill Level and the branch level in the Guddamgill Cross Vein.

Brownley Hill and Brownley Hill North Vein.—The report previously mentioned does not speak so favourably of these veins; the former is stated to be only 4 ft. wide in the Wellgill Level, and to carry only a small quantity of blende at that random, although the amount was greater in the higher part of the Great Limestone. The North Vein is supposed to carry no mineral of value. Wallace (*loc. cit.*, p. 178) remarks that Brownley Hill Vein is about the same magnitude as Scaleburn and Guddamgill Veins, and that it has contained larger quantities of lead-ore than the latter, though less than the former. He further asserts that this vein ceases to contain lead in the strata below the anticlinal axis (which coincides with the divide between the Nent Valley and West Allendale) but that the length of barren ground is comparatively short, since "in Mr. Beaumont's Manor (where the vein is known as Scraithehole Vein) rich deposits occurred in all the strata from the top of the Slate Sills to the bottom of the Great Limestone."

Morpeth's report on the West Allendale Veins, written in 1887, describes the Scraithehole Vein as 5 ft. in width and as having yielded immense quantities of ore from the Little and Great Limestone and other Sills above the adit-level (which runs under the Great Limestone) and mentions the existence of extensive flats. The sills below the level had not been proved.

The six strings west of Brownley Hill North Vein.—In a Report on the Brownley Hill Veins five of these strings are said to carry blende in the shale below the Quarry Hazle, and the other, which in this bed was barren and only 2 ins. wide, was followed into the Great Limestone for 70 fthms., and

[1] "Mineral Deposits," 1861, pp. 178–181.

there proved to be 4 ft. wide, and to contain a considerable quantity of lead-ore and a little blende.

The Wellgill Cross Vein.—Wallace states (*loc. cit.*, p. 181) that this vein contained rich deposits of galena east of Guddamgill Burn but became poorer north-westwards, and was quite barren for some distance beyond the Brownley Hill Vein. Still further on, however, where the Nentsberry Haggs Vein, had it persisted, would have crossed it, the vein again carried much ore. According to the report on the Brownley Hill Veins, the Wellgill Cross Vein was particularly rich where it is cut by the strings above mentioned.

Guddamgill Burn Cross Vein.—Wallace (*loc. cit.*, p. 181) noted the vein as containing much ore between Guddamgill and Brownley Hill Veins. It is also reported as rich in galena where the strings cross it. Near that point it was cut by a drift from the Wellgill Level and worked for a few fathoms in the two directions, but it has not been followed further west.

Brownley Hill Cross Veins.—These have all been worked for lead and zinc north of the N.E.–S.W. veins, but beyond these, with the exception of the Jug Vein, they waste away. The richest deposits in the High Cross Veins according to Wallace (*loc. cit.*, p. 180) were found where the Middle and Sun Veins, if they had persisted, would have cut them. Some lead-ore was raised from the Brownley Hill West Cross Vein in the Quarry Hazle and Four Fathom Limestone. These deposits occur directly below the rich ground in the Great Limestone, but are poor as compared with the latter.

The Brownley Hill Veins were all traversed by levels from the Wellgill Level or its northern branch. Access to the Moss and High Cross Veins was obtained from the workings in the Brownley Hill Vein, and the Jug Vein was reached by cross-cuts from these and also from the Sun Vein. The following facts relating to the early history of the mine are given on the authority of Wallace.[1] It was worked to some extent in the Slate Sill prior to the general letting of mines by the Greenwich Hospital in 1735, but no offer was made for it, and it was regarded as worthless by the agents. It was leased to Thos. Westgarth in 1748, and to William Armstrong and William Hutchinson in 1765, who raised a large quantity of ore from the cross-veins and the principal east-and-west veins. The lease was transferred to the Brownley Hill Company in 1795, and to Jacob Walton and Thos. Shaw in 1816.

The Nentsberry Veins (*Nentsberry or Haggs Mine*).—The Nentsberry Veins occupy a small plot of ground west of the Brownley Hill Veins, between Nentsberry Bridge and High Nentsberry. They outcrop in the Great Limestone on the south side of Carr's Vein, against which they appear to terminate.

[1] "Alston Moor: its Pastoral People: its Mines and Miners," p. 123.

Five veins have been proved, namely, the Nentsberry Haggs Vein, the Nentsberry Haggs North Vein, the Nentsberry Greens Sun Vein, and Nentsberry Greens North Vein, and an unnamed vein; the last mentioned strikes N. by E.–S. by W., the others N.E.–S.W. None have been proved for more than a short distance, but they are in the same general line as the Fletcheras and other veins on the south side of the Nent. The refuse from the workings is largely ferruginous country-rock and rider, containing indications of blende, with traces of barytes.

The veins were worked mainly in the Great Limestone. Wallace (*op. cit.*, p. 213) states that Nentsberry Haggs Vein is the only one that has contained much lead-ore, and that chiefly in the Four Fathoms Limestone and Nattrass Gill Hazle; near the Alston and Nenthead Road, ore was found as low as the Three Yards Limestone according to the same authority.

The chief entrance to the workings was by the Nentsberry Level, which follows the Nentsberry Haggs Vein as far as Carr's Vein, and then turns in a northerly direction until it intersects the Wellgill Level. This adit-level is still used as a means of access to the High Raise Vein. The entrance, which can be seen by the side of the road, is situated below the Four Fathom Limestone. A still higher level along the same vein has its mouth a little distance above the road.

From the Nentsberry Level a short drift has been carried along the Cowhill Vein, which it cuts, and from this a little galena and calamine have been obtained. A level, with its adit close to the road, has also been driven along the most westerly of the veins.

The High Raise Vein.—The vein runs parallel with the other great lodes of the district at a distance of two-thirds of a mile west of the Brownley Hill Veins. Its line of bearing is almost identically that of the Nentsberry Greens North Vein, but it is not known south of the Wellgill Cross Vein.

It is entered by a flank-level from the Wellgill Level at a point north of the latter, and the workings, now extending a quarter of a mile into Northumberland, are being advanced in virgin ground; they are confined to the Great Limestone and the Quarry Hazle, chiefly to the former.

In the present workings the vein maintains a fairly constant thickness of 7 ft. It has practically no hade, and the greatest downthrow to the N.W. is 10 ft.

The contents vary rapidly; at the southerly part of the workings the vein carried barytes and witherite, and only a small quantity of blende. An insignificant fault (2 in. displacement) then crosses it, and beyond this, and up to the county-boundary, its contents consist of blende and witherite intimately intercrystallised, but include little or no lead. Immediately upon entering Northumberland the vein again becomes a blende-vein, similar to those to the east. Galena

reappears and forms two, and in some places three, strong persistent ribs. This change also is stated to coincide with an intersection by an insignificant fault.

The vein, as seen in the present workings, is compact and solid, little prone to forming flats, but accompanied by numerous strings which fly off and rejoin it.

In the case of the mixed minerals described above, the separation of the blende from the witherite proved impracticable by mechanical means, and had to be effected by the solution of the barium carbonate by hydrochloric acid after the galena had been removed at the mine by jigs. The barium carbonate was recovered by precipitation.

Summary of Returns.

Rampgill Vein.

Lead-ore, 1848–82, 35 years	10,562 tons.
Lead, 1848–75 (1855–6 missing), 26 years	6,148 tons.
Silver, 1861–75, 15 years	25,413 ozs.
Metallic lead in lead ore	73·5 per cent.
Silver per ton of lead	7 ozs.

Scaleburn Vein.

Lead-ore, 1848–82 (1876–7 missing), 33 years	2,277 tons.
Lead, 1848–75 (1855–6 missing), 26 years	1,376 tons.
Silver, 1854, 1861–74, 15 years	4, 182 ozs.
Metallic lead in lead-ore	73 per cent.
Silver per ton of lead	7 ozs.

Guddamgill Vein.

Lead-ore, 1848–82, 35 years	3,572 tons.
Lead, 1848–75 (1855–6 missing), 26 years	1,283 tons.
Silver, 1854, 1861–75, 16 years	6,233 ozs.
Metallic lead in lead-ore	73 per cent.
Silver per ton of lead	7 ozs.

Carr's and Hanging Shaw Veins (East of Nent).

Lead-ore, 1848–82, 35 years	10,562 tons.
Lead, 1848–75 (1855–6 missing), 26 years	6,815 tons.
Silver, 1854, 1861–75, 16 years	35,861 ozs.
Metallic lead in lead-ore	74 per cent.
Silver per ton of lead	7 ozs.

Carr's Vein (West of Nent).

Lead-ore, 1848–74 (4 years missing), 23 years	309 tons.
Lead, 1848–74 (4 years missing), 23 years	219 tons.
Silver, 1854–74 (5 years missing), 16 years	819 ozs.
Metallic lead in lead-ore	71 per cent.
Silver per ton of lead	6·5 ozs.

Wellgill Cross Vein.

Lead-ore, 1848–61 (1852 and 1860 missing), 12 years	513 tons.
Lead, 1848–61 (1852 and 1860 missing), 12 years	352 tons.
Silver, 1854–56, 3 years	420 ozs.
Metallic lead in lead-ore	69 per cent.
Silver per ton of lead	6·5 ozs.

Nentsberry Veins.

Lead-ore, 1852–1912 (11 years missing), 50 years	1,366 tons.
Lead, 1852–1912 (14 years missing), 47 years	1,002 tons.
Silver, 1854–1904 (18 years missing), 33 years	3,506 ozs.
Metallic lead in lead-ore	77 per cent.
Silver per ton of lead	6·5 ozs.

Brownley Hill Veins.

Lead-ore, 1848–86, 39 years	14,689 tons.
Lead, 1848–86 (1884–5 missing), 37 years	10,651 tons.
Silver, 1854–84, 31 years	45,991 ozs.
Metallic lead in lead-ore	73 per cent.
Silver per ton of lead	5 ozs.

Zinc Ore Returned:—

	Tons.
NENTHEAD, 1872–1918	163,460
NENTSBERRY, 1874–1918 incomplete	11,875
BROWNLEY HILL, 1872–86 incomplete	1,198
	176,533

Blagill Mines.

(*Disused.*)

Maps.—One-in. (Geological) Old Series, Sheet 102 N.E. New Series, Sheet 25. Six-in. (Geological) Cumberland, Sheet 34 N.W.

Blagill is a name of a small, although comparatively wide valley cut in the northern slope of the Nent Valley, 1¼ miles east of Alston, but the group of Blagill Veins extends from east of Foreshield Burn through Blagill to the South Tyne Valley, a distance of more than 2 miles. The Blagill Veins lie to the south of the long Nenthead Cross Veins.

The most important vein of the group is the Thorngill, which strikes almost due east and west, and is known at its eastern end as Lough Vein. It crosses Blagill Burn 700 yds. north of the Nent and throws the strata some feet to the north. Fistas Rake or Blagill Old Vein, ranks next in importance. Several shorter veins branch from or intersect these, and on the west of the complex are two other N.E.–S.W. veins—the Whitewell and the Slote Veins. Thorngill and Fistas Rake are cut off to the east by Blagill Cross Vein.

The matrix of these veins is witherite and barytocalcite together with some barytes. Blende is present but only in small amount. Galena has not been obtained in great quantity, but nevertheless the veins have been worked as lead-mines for a long period; more recently they have been worked in a small way for their barium spars.

The veins have been proved most productive under Blagill itself, and there the Thorngill Vein has been worked from the Firestone to the Nattrass Gill Hazle. Under the ridge between the Blagill Burn and the South Tyne, the "Thornhill Veins"

have, according to Wallace,[1] produced no lead, but west of the ridge the Thorngill Vein contained a rich deposit of ore, which, however, was restricted to the strata above the Great Limestone, though the "Sun Vein"[2] was poor here. The Slote Vein carried no ore under Newshield Moor, but yielded a little further west.

Blagill Old Vein or Fistas Rake Vein is reported to have produced much lead-ore in the Quarry Hazle and the Four Fathom Limestone in a short length of ground adjacent to the Blagill Cross Vein, but trials in lower strata proved unsuccessful. On the south side of Fistas Rake Vein a portion of the Blagill Cross Vein, about 40 fthms. in length, contained much lead-ore in the Quarry Hazle.[3]

Although the complex of veins is not extensive, the different members of it, and even different parts of the same vein (in the case of Thorngill), have, as far back as we have record, been worked as independent concerns.

Of the many adits known, the mouth of Thorngill Low Level is situated 200 yds. north of the Nent, and that of the High Level some distance further up the valley. The former enters the ground about the horizon of the Three Yards Limestone. The London Lead Company held the lease of a part of the mines in 1736 at the time the estate was acquired by the Greenwich Hospital.[4]

North of the Blagill Veins are the Taylor's Grove, the Clargill[5] and the Ayleburn Veins. These trend almost due east and west, and are cut off in the latter direction by a north-and-south vein running from Ayleburn towards Alston through Newshield. These are all inferior veins, and Wallace[6] states that the lead-ore deposits in Taylor's Grove Vein "have been very poor, and so far as proved have not repaid the cost of extraction," and that Clargill and Ayleburn Veins are proved to a considerable extent, and found to contain very little ore. These remarks have been confirmed by other information. The workings in Taylor's Grove and Clargill Veins are situated 1 and $1\frac{1}{2}$ miles respectively north of Alston; they were little more than trials.

Summary of Returns.

Blagill Vein.

Lead-ore, 1848–81 (1871–2, 1879 missing), 31 years	1,192 tons.
Lead, 1848–81 (1871–2, 1879 missing), 31 years	853 tons.
Silver, 1854–81 (6 years missing), 22 years	2,664 ozs.
Metallic lead in lead-ore	71·5 per cent.
Silver per ton of lead	6 ozs.

[1] "Mineral Deposits," p. 184.

[2] No Sun Vein is shown on the map *west* of the ridge, but one is mapped on the east side; Whitewell Vein, however, lies on the south side of the Thornhill and to the west of the ridge.

[3] *Ibid.* pp. 226–7.

[4] Wallace, "Alston Moor: its Pastoral People: its Mines and Miners," 1890, Appendix II.

[5] Clargill is also the name of a mine near the head of the South Tyne

[6] *Op. cit.*, p. 185.

Thorngill, East End.

Lead-ore, 1851–64, 1869, 15 years	206 tons.
Lead, 1851–64, 1869, 15 years	147 tons.
Silver, 1854–64, 11 years	856 ozs.
Metallic lead in lead-ore	71·5 per cent.
Silver per ton of lead	6·5 ozs.

Thorngill, West End.

Lead-ore, 1849–63, 15 years	219 tons.
Lead, 1849–63, 15 years	146 tons.
Silver, 1854–63, 10 years	557 ozs.
Metallic lead in lead-ore	67 per cent.
Silver per ton of lead	7 ozs.

Ayleburn Mine.

Maps.—One-in. (Geological) Old Series, Sheet 106 S.E. New Series, Sheet 19. Six-in. (Geological) Northumberland, Sheet 106 S.W.

Site.—Two thirds of a mile east of Ayle and 2 miles north of Alston.

Lead-ore has been obtained from the Ayleburn Vein and also from the north-and-south vein. The Ayleburn Vein which throws down north some 24 ft. has been intercepted by a level carried some fathoms beyond it. This was constructed by the London Lead Company. Its mouth is situated below the Great Limestone close to where the road-bridge across the stream bears on its keystone the date 1824. From the map one must infer that the Ayleburn has not been followed very far west of the adit level. The north-and-south vein is entered by an independent level which also has its mouth near the stream, and which runs along the vein in a northward direction.

The official statistics include no lead-ore returns from the mine, though returns of 75, 7 and 40 tons of blende are recorded for the years 1894, 1895 and 1896 respectively.

Witherite lies around the water-wheel (on the south side of the stream) and blende, mostly in hard sandstone, litters the heaps near the old level-mouth.

The level communicates by means of a rise with a series of natural caves in the Great Limestone which have been described by Sopwith.[1]

A witherite-vein in line with Taylor's Grove Vein is shown on the geological map within a bend of Ayle Burn, ½ mile south-west of Ayle.

Barhaugh.

Still further north than the veins just described is an east-and-west line of fracture, consisting of a number of small faults. This is seen in the banks of the South Tyne, at the confluence of the Barhaugh Burn, and has been proved in the

[1] "An Account of the Mining District of Alston Moor," &c., 1833, pp. 64–67.

Barhaugh Colliery a mile to the east. In the same general line, but a mile west of the river is a vein of ochre, now being worked S.E. of Slaggyford. A north-and-south fault crosses the east-and-west fracture about 750 yds. east of Barhaugh Park. Eastward from the park the track of the latter is marked by ancient heaps of lead-scoria and wood-charcoal, strongly suggesting that ore has been obtained here and smelted at some remote period. The piles of loose stones seen in the gullies may be the remains of dams of old hushes. More recently, probably early in the 19th Century, a level has been driven under the hill from the side of Barhaugh Burn, close to the present colliery. About 100 yds. in, the level branches, a shorter branch running north-east, and a longer one (400 yds. in length) bearing to the east of south towards the point of intersection of the north-and-south with the east-and-west faults. The level does not seem, however, to have been carried far enough to cut any faults.

The Compressed Air Plant, Nenthead Mines.

Compressed air is employed in these mines for all purposes, pumping, hoisting, drilling, as well as for ventilation, and except in periods of drought, is produced by water-power. The system is of a kind that, up to the present, has received but little application in this country. Yet the plant supplies compressed air without any other expense than the upkeep of the reservoirs and pipes, and requires little attention. The following notes were drawn up with the help of Messrs. Dupont and Cox of the Vieille Montagne Zinc Co.

The water is collected in reservoirs on the surrounding hills, and is conveyed to the top of shafts by pipes which are there connected with descending pipe-lines. Here air is admitted by means of small internal pipes and holes in the sides of the pipe-line, and the supply is controlled by stopping some of the holes.

The air is drawn down the pipe-line by the descending column of water and carried down into a bell-shaped "air receiver" into the top of which it rises. The water escapes through an ascending pipe to a height of almost 200 ft. and provides the weight necessary to compress the air to something like a pressure of 90 lbs. per sq. in. The overflow of water is then brought down a third pipe-line and, where circumstances permit, is re utilised.

Three reservoirs supply the plant with water, namely, Perry Dam, capacity 16,500,000 galls., situated 1,900 ft. above O.D.; Smallcleugh Dam, capacity 375,000 galls situated 1,600 ft. above O.D.; and Coalcleugh Dam, capacity 2,600,000 galls., situated 1,800 ft. above O.D. Perry and Smallcleugh Dams lie to the south of Nenthead; Coalcleugh Dam is in West Allendale.

Three shafts are fitted with pipe lines, namely Bogg Shaft, Brewery Shaft, and Barney Craig Shaft. The water from Perry Dam compresses air at the bottom of Bogg Shaft and overflows into Smallcleugh Dam. That from Smallcleugh Dam compresses air by means of the same apparatus in Brewery Shaft, overflows to a height of 200 ft., and then descends again to work a Pelton Wheel, driving an ordinary reciprocating air-compressor. From the Pelton Wheel the water escapes into the Nentforce Level.

The Brewery Shaft is 328 ft. deep and has a water tower about 90 ft. high erected above it; the water rises to the top of the tower by virtue of its own head and has therefore a fall of 400 feet. If necessary this shaft can be supplied directly by Perry Dam.

In the Barney Craig Shaft water from Coalcleugh Dam is brought by a pipe-line and used in driving a compressor by means of a Pelton Wheel.

Under usual conditions the amount of air compressed in the air-receivers is $2\frac{1}{2}$ cub. ft. of air per cub. ft. of water. The air is carried through the mines by pipes and used as required.

A steam-driven compressor-plant is kept in repair for use in case of drought or accident to the water-plant, but is hardly ever required.

The mines are drained by levels, consequently little pumping is required except in the case of the lowest workings, below the Rampgill and Barney Craig adit-levels. Where pumping is necessary the system known as the "Mammoth" is employed. Compressed air enters at the bottom of a vertical pipe-line, the open end of which stands in water. The air ascends and draws the water up with it. When the rock-drills are in use pumping is discontinued in order to maintain satisfactory pressure.[1]

Treatment of Ore at Nenthead.

The dressing-plant, a building of five stories erected in 1909, is situated at the village of Nenthead and the machinery is of the most modern type. The conversion of the crude ore into a marketable product is a continuous process, the material passing automatically from the earliest to the final stages. Throughout the whole operation there is repeated washing of the intermediate products, to ensure against loss of ore in the waste.

The plant is capable of dressing 200 tons of ore in 12 hours, but since the war the produce of the mines has, through the lack of miners, been insufficient to feed it, and the ore raised from the mines has been treated along with material from the old waste-heaps. During 1918 150 tons of material were being

[1] A brief account of the plant will be found in the *Trans. Inst. Min.* and *Mech. Eng.*, Vol. XLVI., 1914, pp. 149–156. It contains some technical details omitted here.

dressed daily, and of this only 40 per cent. was mine-ore. The lead-and-zinc-contents of crude and dressed ore are :—

	Lead per cent.	Zinc per cent.
Crude ore - - - - -	8·0	2·0
Dump material - - - -	3·5	0·75
Dressed galena - - - -	77·0	—
Dressed blende - - - -	—	42·0

Pyrites and siderite are present to a considerable amount and their separation from the blende renders the process of concentration a difficult one.

Hand-picking and crushing :—

The crude ore is elevated by an outside hoist to the uppermost floor, wheeled into the building, and weighed upon a self-registering machine. It is then taken to the tipper which, gripping the waggon, revolves and empties the contents through a hopper into a revolving screen. The screen consists of an inner and an outer drum, the former perforated with holes 65 millimetres in diameter. and the latter with 20-millimetre holes. The material is thus sized into pieces :—(1) above 65 millimetres ; (2) between 65 and 20 millimetres ; (3) below 20 millimetres (which goes directly to trommels and jigs). The coarsest material falls directly on a revolving circular table 4 metres in diameter, worked by means of a central ring-shaft ; the clean galena and refuse are both picked out. The rest is swept mechanically into a stone-breaker and thence passes into a second screen of one drum only, perforated with 20-millimetre holes. The material retained by the holes falls upon a second revolving table 5 metres in diameter, which runs on wheels driven by gearing. This material is again hand-picked. The remainder is automatically crushed between a double set of rollers, which reduces it to fragments below 20 millimetres. From these rollers it passes into the shoot and is dropped into the elevator which carries it to the screening trommels that serve the jigs.

The medium-sized ore (pieces between 20 and 65 mm.) is fed directly by the first screen on the second revolving table, but falls on the outer edge, whereas that which has passed through the first crusher falls near the inner edge. After it has been picked over it passes along with No. 1 through the rollers.

The progress of the ore from the first screen to the elevator is diagrammatically illustrated in Plate 15.

The Jig Department.—There are 38 jigs, installed on two floors, 28 on the upper and 10 on the lower. Of those on the upper floor, 18 wash crude ore and 10 the product of the preliminary washings, known as "middlings." The 10 jigs on the lower floor wash the middlings received directly from those washing the crude ore above them. The

jigs wash ore of various sizes from 20 millimetres down to 1 millimetre, viz. :—20 to 15, 15 to 10, 10 to 7, 7 to 5, 5 to 4, 4 to 3, 3 to 2, 2 to 1, millimetres. Particles less than 1 millimetre are carried forward to the slimes-house. The jigs that wash the two coarsest grades, *i.e.*, particles above 10 millimetres, merely separate galena and waste from the crude ore, but the rest yields five separations, viz. :—(1) galena, (2) rich middlings, that is, mixed galena and blende, (3) blende, (4) poor middlings that is, mixed blende and waste, and (5) waste. The galena and blende are discharged through pipes into receivers and the middlings (except in the case of the three coarsest grades) into the jigs on the lower floor.

The middlings from the jigs washing the three coarsest grades are crushed, and then conveyed along with the middlings produced by the jigs on the lower floor to the 10 jigs allocated for that purpose that stand on the upper floor by the side of those washing crude ore. The rich middlings and poor middlings are kept separate.

The middlings that these jigs in their turn yield are crushed very fine and then allowed to pass into the slimes-house.

The water which carries away the waste is drained from the solid material and pumped into tanks situated outside the building, and is utilised over and over again. The sediment collected in these tanks is re-treated. The waste from the jigs, together with refuse picked off the revolving tables, is conveyed from a platform on the hoist to the spoil-heaps by an aerial ropeway electrically driven.

The Slimes-house.—The finest material is dressed on tables on the ground floor. The slimes, both from the crude ore and from the middlings, are treated separately, although the treatment is identical throughout all stages.

The material is pumped into the settling tanks and from there to hydraulic classifiers which distribute it among the tables according to fineness. The coarsest is received on shaking concentrating-tables, the intermediate grade on vanning-tables, and the very finest on circular tables.

There are 48 tables in all, viz. :—22 shaking concentrating tables covered with linoleum, 4 metres long and $1\frac{1}{2}$ metres wide, 20 mechanically fed and 2 hand-fed; 10 vanning-tables with endless rubber belts and of slightly smaller dimensions, 8 fed mechanically and 2 by hand; 16 circular revolving tables of 4 sizes (4, 4·5, 4·75, and 5 metres diameter) covered by cement; these tables are arranged in tiers of two.

The rectangular tables operate by means of an eccentric motion, and the material is washed by jets of water from a spray diagonally placed. The circular tables are modifications of the old-fashioned buddlers, and the slimes are washed by water falling on the centre of the tables which are slightly conical.

The shaking-tables and vanning-tables yield, as do the jigs, (1) galena, (2) rich middlings, (3) blende, (4) poor middlings, (5) waste.

Half of these tables are directly fed from the settling-tanks, while the other half receive the middlings produced by the first row; these are designed so that alternate tables receive rich and poor middlings respectively. The rich middlings produced in this second washing are collected into receivers and conveyed by hand to one of the two shaking-tables reserved for the purpose. The poor middlings are carried by water into a canal running underneath the tables, and are pumped back into the tanks. The waste is carried away by another canal similarly situated.

The circular tables yield (1) mixed galena and blende, (2) blende, (3) waste. The waste is carried away by the water, and the other separations are distributed as bands concentric with the edge of the table.

The blende which forms the outer band is caught by a small brush and the mixed blende and galena by a longer one placed a little distance behind. The two separations are swept into receivers.

The mixed galena and blende are washed on the hand-fed vanning-tables.

The water from the round tables is pumped into the same reservoir as the water from the jigs.

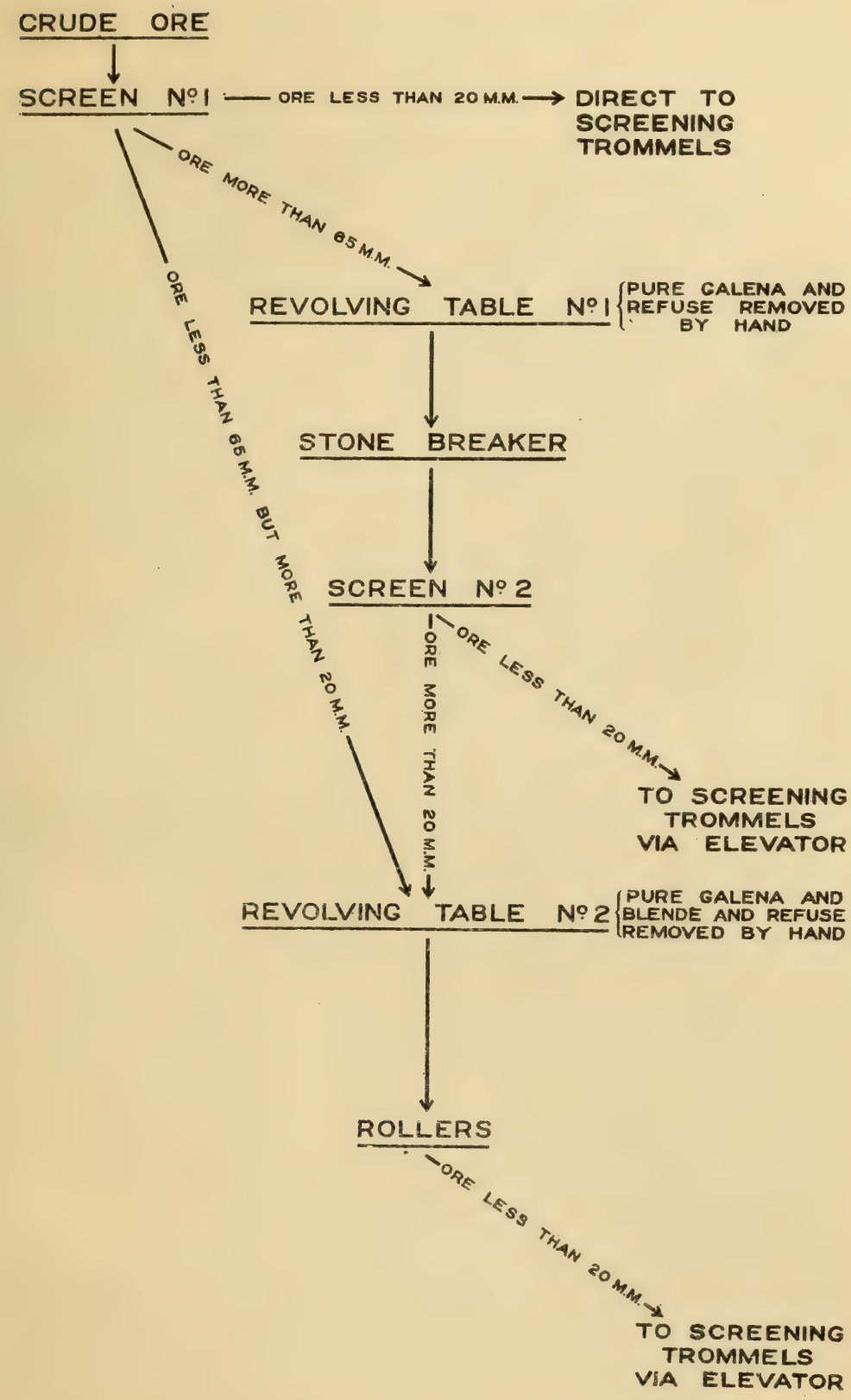
Part of the slimes-blende is furthermore concentrated by the removal of the iron carbonate; this is done by means of an electro-magnet. The ore is first dried in a revolving dryer and then conveyed by means of an endless rubber-belt over the magnet but under a revolving iron disc which picks up the iron carbonate and iron particles produced by abrasion from the machinery, and carries them beyond the magnetic field.

THE UPPER SOUTH TYNE.

General Account.

The remainder of the Alston field, from the Nent southwards to Cross Fell, is occupied by horizontal Yoredale sediments, ranging from the Tynebottom Limestone up to the Lower Fell Top Limestone on the summit of Middle Fell. The great majority of the mineral veins trend S.W., carrying galena and blende in a quartz or calcite matrix. There are only two S.E. cross-veins of any account; (1) the Hudgill or Black Ashgill Cross Vein, traceable for 5 miles along the S. side of the Nent Valley, and (2) Sir John's Vein, which can be followed for at least 7 miles up the South Tyne to the watershed.

The Great Sulphur Vein traverses the southern part of the area, running E. by S. for at least 6 miles. This remarkable belt of disturbance carries no ore-bodies of any value, but is full


CRUDE ORE
SCREEN Nº 1
ORE LESS THAN 20 M.M.
DIRECT TO SCREENING TROMMELS
ORE MORE THAN 65 M.M.
ORE LESS THAN 65 M.M. BUT MORE THAN 20 M.M.
REVOLVING TABLE Nº 1
PURE GALENA AND REFUSE REMOVED BY HAND
STONE BREAKER
SCREEN Nº 2
ORE MORE THAN 20 M.M.
ORE LESS THAN 20 M.M.
TO SCREENING TROMMELS VIA ELEVATOR
REVOLVING TABLE Nº 2
PURE GALENA AND BLENDE AND REFUSE REMOVED BY HAND
ROLLERS
ORE LESS THAN 20 M.M.
TO SCREENING TROMMELS VIA ELEVATOR

FLOW SHEET AT THE NENTHEAD MINES.

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of vein-quartz; on occasion, as at Noonstones Hill and S. of Rotherhope Fell, the shatter belt may be a quarter of a mile across.

Detailed Descriptions.

Galligill and the South Tyne Valley.

There are numbers of old mines, now long disused, in the rectangular block between the Nent and South Tyne Valleys. Most of the lodes were highly productive in the Firestone Sill and Great Limestone, but below that they pinched out. An example is the Galligill Sike North Vein, S.W. of Nentsberry; this was wrought successfully from the Tuft (*i.e.*, the soft sandy fire-clay underlying the Great Limestone), but when a shaft was sunk to the Four Fathom Limestone and a trial drift made, the lode proved useless, and the workings had to be abandoned. These features are repeated along the hill-side facing the South Tyne up to Garrigill Beck; out of 23 galena lodes wrought in this tract only two (Fletcheras and Dowpot Sike Veins) were of any value below the Great Limestone, and even these were of little account. The remainder do not call for extended notice, since they were easily wrought from adit levels, and were exhausted; one of the lodes (Holyfield Sun Vein) gave valuable "flats" presumably of the metasomatic type, in the Great Limestone about half a mile in from the outcrop; calamine was got in this mine, as well as in Farnberry Old Vein, 250 yards to the N.W.

At Garrigill lower strata become productive. There are two master-veins here, each traceable for at least 4 miles. One of these, the *Bentyfield Vein*, though of little account S.W. of the river (where it is known as the High Scar, or Great Vein) improved greatly to the N.E., in which direction it crosses the hilltop to join the Greengill Vein in the Nent Valley. The lode is on a small fault, down north 3 or 4 ft.; one of the old levels entered the vein in the Scar Limestone immediately below the waterfall in Garrigill Burn. Higher upstream are cross-cuts in the Four Fathom and Great Limestones, and in the Lower Coal Sill. These were continued S.E. to intersect the *Browngill Vein*, of which there is an excellent section in the South Tyne at Beldy Mill. The lode here crosses the Tynebottom Limestone, which is brought up along the river-bed in a gentle anticline. The vein is 10 ft. wide, and is mostly filled with black chert, spangled with galena dust; on the south cheek there is a little iron pyrites. A line of old shafts leads up the hillside as far as the opencast south of Nunnery Hill; here the lode divides, one branch going N.E. to join the Rampgill Vein at Nenthead, while the other turns E. to the Caple Cleugh Vein.

In the neighbourhood of the South Tyne, the Browngill Vein certainly carried good ore-bodies down to the Tynebottom Limestone, but elsewhere we have no knowledge of any workings below the level of the Four Fathom Lime. As there would be no difficulty in draining the lower strata, one must conclude that away from the river the lode ceased to carry ore in depth. This supposition is confirmed by an old section preserved in the offices of the Vieille Montagne Company at Nenthead. This shows that the North Side Vein (an offshoot, 10 ft. down south from the Browngill lode S.W. of Nunnery Hill) carried "very rich ore" in the High Coal Sill, but in the Low Coal Sill was poor, and a trial shaft down to the Great Limestone proved useless.

The old Tynebottom Mine at Garrigill was opened on the *Windshaw Bridge Vein*, running (contrary to the general rule) in a S.E. direction. The mouth of the main level was alongside the river 500 yds. N.W. of the village, where the road skirts the water's edge. This mine had a good reputation in old times, and from the size of the refuse heaps much material must have been got out. The bulk of the ore probably came from the Tynebottom Limestone, as the drainage of lower strata would have been most difficult in the old days. Extensive "flats" were got, and although Wallace states that they were not so good as those so often found in the Great Limestone, their occurrence at such a low horizon is of much interest. The Whin Sill lies immediately under the Tynebottom Limestone here, and it is on record that "in the Tynebottom Mines some of the veins have been partially explored in the Whin Sill, where they were found filled with calcite and spathose iron ore, but containing no galena."[1] The prospects for a further exploration in depth, down to the Melmerby Scar Limestone, are therefore not hopeful.

The Windshaw Bridge Vein can be followed upstream from the Tynebottom Mine as far as Mid Ashgill Steading, a distance of $1\frac{3}{4}$ miles. There are old shafts on the lode south of Ashgill, but the vein seems to die out in that direction, as little work has been done. On the right bank of the river, 430 yds. W. of Mid Ashgill, a level was driven in the shale over the Tynebottom Limestone, up to Low Ashgill Farm. There the Potato Garth Vein, running W. by S., was struck, and a large "flat" wrought in the limestone. Across the river, 250 yds. S.S.W. from Howgillside Farm, a trial is now (1919–20) being carried on in the Scar Limestone; no definite vein has been struck, but there are many small cavities in the limestone filled with calcite and, occasionally, with galena, which may perhaps denote the vicinity of a valuable "flat."

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[1] H. Louis, "A Treatise on Ore Deposits," 2nd Edit., 1896, p. 277.

Sir John's Vein has been frequently tried, and to some extent wrought, for copper ores, but has yielded very little galena. There are traces of the mineral in the waste heaps at Tynehead Mine, by the riverside, and recent trials by Cross Gill have yielded some ore, along with much quartz and spathose iron; similar results attended at a trial of the veins in 1882, alongside Dog Burn, nearly 2 miles to the N.W. Sir John's Vein, though so strongly marked (it may be 20 ft. wide on occasion) has hitherto proved a disappointing subject; the most extensive trial was probably at Tynehead Mine, where the workings were carried across the Great Sulphur Vein, on the far side of which the lode was again picked up, but in no better condition.

There are several small galena veins in the Great Limestone above the main road east of Tynehead; in lower strata they cease to be productive, and one of them, the North Windybrae Vein, seems to change its character, for in the valley bottom, just below the waterfall in Clargill Burn, it carries copper pyrites in a quartz and dolomite matrix: a trial drift has been cut here in the Scar Limestone, and traces of gold are reported to have been got; analysis of some of the ore did not confirm this assertion.

Towards the head of the South Tyne the Whin Sill appears underneath the Tynebottom Limestone; it is seen in the river immediately south of the shatter belt which marks the Great Sulphur Vein, and terminates at the fork in the stream above Tynehead Smelt Mill, where the Limestone is brought down against the whin by a S.E. fault, with a throw of 80 to 90 ft. The dislocation is noted on the published Geological Survey map (1-in. scale) as an ordinary fault line; it is, however, mineralised, and has been wrought from levels driven in near the river, and along Allen's Cleugh, at the head of which a good deal of galena is still lying about on the waste heaps.

Opposite Shellwell steading an east-and-west dolerite dyke, presumably of Tertiary age, crosses the river, meeting the north-easterly *Calvert-fold Vein* about 400 yards to the W. This vein has been worked, but so long ago that definite information as to the nature of the junction could not be obtained. Nearly 2 miles further W. the same dyke again meets a mineral lode (the *Doups* or *Douks Burn Vein*) and Professor Louis records that "where opened upon by mining-operations . . . . . no trace of the vein was seen in the dyke, but when the latter had been cut through, the vein was found in its proper position on the other side. It therefore appears that the intrusion of the whin dyke was posterior to the formation of the metalliferous east and west veins of Alston Moor."[1] This information is of very considerable interest; it is practically the only definite evidence we have in the North of

[1] H. Louis, "A Treatise on Ore Deposits," 2nd Edit., 1896, p. 276.

England from which the relative age of the mineralisation can be deduced.

Near the source of the South Tyne, the Calvert, Doses, and Tynegreen Mines, wrought a number of S.W. lodes, by means of levels which were mainly productive in the Scar Limestone; there was a little blende with the galena, in a quartz-fluorspar matrix. The workings were only on a small scale and from the remote situation of the mines it is improbable that they will ever be reopened.

Rotherhope and Cross Fell Area.

With the exception of the Nenthead workings this is the only part of the Alston Moor Field where mining is still actively carried on.

Rotherhopefell Mine.

Owners.—The Vieille Montagne Company.

Site.—On the right bank of Black Burn, 2½ miles S.S.W. from Alston.

History.—Blackburn's or Low Level, now the chief opening to the mine, was cut about 1837, and presumably the Middle and High Levels were of earlier date. Until about 1900 the workings belonged to the Rotherhopefell Lead Mining Co., who sank two shafts and did much exploratory work; the mine was then taken over by the Vieille Montagne Co., who deepened the shafts, sank a third one in 1907, and carried on work intermittently until 1914; since then further developments have been undertaken and active operations resumed.

Geology, &c.—Rotherhope Cleugh Sun Vein, the main lode, runs S.W. across the western slopes of Rotherhope Fell, and is in line with the Slaggyburn and Crag Green Vein of the South Tyne Valley; it is accompanied by a fault with a throw of 4 fthms. down south, and, as now seen in the workings, is essentially a fluorite-galena lode, with traces of blende. On the surface the vein crosses the Scar, Five Yard and Three Yard Limestones, below which the earlier workings did not extend; at the present time ore is raised from the Tynebottom Limestone and from the Whin Sill beneath.

There are three cross-cut levels: High Level starts from the Three Yards Limestone in Middle Gill, at an altitude of about 1,330 ft., and crossing the vein within 250 yds. continues S.E. for three-quarters of a mile to intersect the Greencastle Tarn Vein. Mid Level starts in the Five Yard Limestone at 1,250 ft. and goes 370 yds. beyond the main lode, up to New Vein, but the latter proved worthless. Blackburn's, or Low Level, opens on the right bank of the Blackburn, at 1,100 ft., in the Cockleshell Limestone, and runs south for 1,000 yds. to Victoria Vein, after which it turns S.S.E. up to the main lode. Low Level,

altogether, is 1,380 yds. long: it ends in the shale or "plate" over the Tynebottom Limestone, and from that point No. 1 Shaft is sunk 56 fthms., with two drifts along the lode at 20 and 43 fthms. respectively. No. 2 shaft is alongside, but goes down to the 20-fthm. drift only.

The main lode averages 6 ft. across, but varies greatly both in thickness and quality. At the shafts it is distinctly poor, and after these were sunk a return was made to higher ground from the Low up to Mid Level, as this had been left intact by the "old men." When the Vieille Montagne Company took over the mine they found that the lode improved away from the shafts, and was quite satifactory in depth also, although towards the shaft-bottom water increased rapidly. In 1919 work was undertaken between Low Level and the 20-fthm. drift: in this tract the ore sometimes gave out entirely for a few yards, the vein being reduced to a mere fissure through the whinstone, the latter being converted to a soft "white trap" for a few feet on either side. Strings of galena then appeared and the whole ore-body suddenly swelled out to a maximum width of 30 ft. The most productive part of the lode lay where the Tynebottom Limestone was faulted against the "whin"; the vein matter was mostly fluorspar, with galena scattered through it; quartz and calcite were in subordinate quantity, while there were traces of pyrites and blende.

Low Level Drift has been opened out for 800 yds. S.W. of No. 1 Shaft, and also for 300 yds. to the N.E., but in that direction is poor, so that the workings have never been connected with the old day-level drift in Rotherhope Cleugh.

Victoria Vein, lying parallel to, and N. of, the main lode, is not of much value. It was explored in 1911, and an old trial "rise" found, reaching from Low Level up to the Scar Limestone, a height of 19 fthms.; a drift had been cut in the Limestone for about 80 yds. Some galena was noticed, and a pocket of blende got 7 fthms. above Low Level. Old workings are also known on the Victoria Vein off Mid Level, where it is said that good ore was got, but there is no reason to think there is any further reserve in depth.

The amount of water in Rotherhopefell Mine varies greatly. At the 20-fthm. drift, below Low Level, it averages 35 galls. per minute, at the 43-fthm. drift only 8 galls., but at the shaft-bottom increases to 60 galls.; for this reason little work has yet been done in the lower workings, although the ore-bodies are satisfactory.

It is of interest to note that power for the rock drills, &c., is obtained very cheaply from a simple type of hydraulic air compressor, similar to that at the Nenthead Mines. Surface water falls 60 fthms. down No. 1 Shaft to the "kettles," whence it rises 30 fthms. to Mid Level and flows away; air at 60 to 80 lbs. pressure is thereby obtained.

The dressing plant is similar to that at Nenthead (*see* pp. 89–92). The Rotherhope installation is smaller, its capacity being 50 tons per shift of 9 hours, and it is designed for galena only. The raw material from the mine averages 8 to 12 per cent. galena, and in the rejected tailings there is rarely more than ½ per cent. of ore.

The Cross Fell Mines.

A group of galena-fluor spar veins, trending S.W., have been wrought on the northern slopes of Cross Fell, at an altitude of 2,500 ft. The chief lode, known as the *West Cross Fell Vein*, is traceable for 3 miles, but the parallel lodes to the north (West Crossfell North Vein, and Katelock Little Vein) are comparatively short.

On Cross Fell itself work was stopped many years ago, but east of the Cashwell Burn a little is still being done on the main lode, which is reached by a cross-cut level driven from the Three Yards Limestone alongside the stream. On meeting the vein a shaft was sunk 30 fthms. deep to the "Copper Hazles" (a sandstone bed under the Scar Limestone). Drifts were run out on the lode from the shaft-bottom, but that to the west beyond the head-waters of Cashwell Burn, proved disappointing compared with higher levels. In the other drift, to the N.E., work was proceeding in 1919; the vein here is said to be from 3 to 6 ft. in width, and yields galena, along with some blende, in a matrix of fluorspar, quartz, and calcite; the fluorspar is notable for its deep purple-blue colour. No "flats" have been observed in the Limestone.

Water in Cashwell Mine averages 80 galls. per minute, and is removed by a hydraulic pump.

Higher up the Cashwell Burn is the mouth of a disused cross-cut, driven in the Four Fathom Limestone, and still further up, 130 yards S.W. of the ruined smelt-mill, is the Low Level, opened almost directly on the main lode. This was the chief drift in the Old Cross Fell Mine, and ran S.W., under the Great Limestone, for 2,000 yards. The High Level, 30 fthms. above, was also on the West Vein, but was only 300 yds. long; 80 ft. above it was West Cross Fell Level (a cross-cut at the head of Slate Sike), from which other drifts were run out, and work was done on the North Vein also, but these higher openings never seem to have been so productive as the Great Limestone or Low Level workings.

The *Katelock Little Vein* was reached from a cross-cut near the head of Black Burn, in the "Tumblers," or uppermost bed of the Great Limestone, and worked for 550 yds. to the N.E. The cross-cut was continued south to the North Vein, and drifts cut for 300 yards on either side. Both veins were tried 600 yards further west in another cross-cut driven from the "Tumbler" beds, but were there of no value.

In the Cross Fell Mines little or nothing has been done below the Great Limestone, and it is possible that good ore-bodies may yet be got below this, though it is only right to note that trials from the present Cashwell workings (Three Yards Limestone horizon) in the direction of Cross Fell are said to be not so encouraging as those to the N.E. The very remote situation of the mines, their high altitude, and the difficulty of transport (9 miles, mostly by a rough hill track from Alston) offer little inducement to reopen the workings.

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